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PHD THESIS

INFORMATION TECHNOLOGY OF ESTIMATION OF DIVERSIFICATION STRATEGIES FOR CONSTRUCTION ENTERPRISES UNDER UNCERTAINTY

126 Information Systems and Technologies
12 Information Technology

Applying for the Doctor of Philosophy degree

The PhD Thesis contains the results of own research. The use of ideas, results and texts of other authors are linked to the corresponding source

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SUMMARY

Li Yuanyuan. Information technology of estimation of diversification strategies for construction enterprises under uncertainty. – *Qualifying scientific work as a manuscript.*

Thesis for the Doctor of Philosophy Degree in Specialty 126 «Information Systems and Technologies». – Taras Shevchenko National University of Kyiv, Kyiv, 2024.

Abstract. The dissertation is devoted to constructing methods, models and information technology for forming, evaluating and selecting diversification strategies for construction enterprises in conditions of uncertainty. The developed methods and models can be used to solve the current scientific and practical task of increasing the management efficiency and profitability of construction enterprises in conditions of insufficient information under the influence of technological, economic, political, social and other external factors, the consequences of which cannot be predicted.

One of the methods that allow solving this problem is the diversification of the activities of construction enterprises. The relevance of the task of diversification for construction enterprises is based on several key factors. The first factor is the demand for the development of the construction industry in conditions of rapid economic growth in countries with favorable conditions. Rapid economic growth is manifested in an increase in the country's GDP, an improvement in the population's standard of living, an increase in employment, the development of infrastructure, an increase in the volume of trade and foreign investment, etc. The People's Republic of China is known for its impressive economic growth over the past decades. This achievement was possible due to the rapid pace of industrialization, an export-oriented approach to the economy, and the comprehensive implementation of reforms. Diversification can help businesses use their resources, such as human resources, equipment, and technology, more efficiently by expanding their applications in different markets or industries. Diversification can give a construction company a competitive advantage,

providing it with a more flexible and adaptive business approach that will expand the range of services to meet the needs of different customers. However, the construction industry is known for its high vulnerability to economic fluctuations and changes in the market situation, economic situation, political turbulence and conflicts.

That is why, in these conditions, several unresolved issues arise. More studies need to be conducted regarding including a separate diversification center in the company's organizational structure, whose activities aim to form, evaluate, and choose the company's diversification strategies. Also, in the case of horizontal integration, the influence of the choice of construction technologies and the choice of the values of the technical and economic parameters of construction on the choice of the diversification strategy of the construction enterprise has yet to be clarified. There needs to be sufficiently reliable methods of evaluating and selecting diversification strategies that would provide an opportunity to increase the profitability of construction companies.

The creation of methods and models for forming, evaluating, and selecting diversification strategies for construction enterprises will increase their productivity and profitability and expand theoretical and practical developments in this direction.

Therefore, this dissertation solves an important task, namely, the development of models, methods and information technology for choosing rational strategies for the diversification of construction companies, which is characterized by taking into account changes in the structure of organizational environments of companies and organically combines the entire range of activities of companies in conditions of uncertainty (scientific component). Automating the evaluation and selection of diversification strategies is also solved. The developed methods and models are integrated into the relevant information technology (practical component).

The object of the study is the processes related to the evaluation and decision-making regarding the choice of diversification strategies for construction companies in uncertain conditions.

The subject of the research is the methods, models and information technology of managing the activities of construction companies in terms of forming, evaluating and choosing rational diversification strategies in conditions of uncertainty.

Research methods. The research is based on knowledge presentation and processing methods, evaluation methods, monitoring of construction companies and their organizational structures, object-oriented programming, project management.

The study aims to develop methods, models, and information technology for evaluating and choosing diversification strategies for construction companies to manage their activities in uncertain conditions.

The scientific novelty of the obtained results:

• for the first time, a model for choosing rational diversification strategies of construction companies is described based on an expert assessment of the technical and economic parameters of construction, which takes into account the most significant indicators and allows taking into account the advantages of participants in the construction process.

• the method of evaluating diversification strategies of construction companies has been improved, which is distinguished by taking into account changes in the structure of organizational environments of companies, which is characteristic of conditions of uncertainty and allows to increase the efficiency of their management.

• the method of forming diversification strategies has been improved, which takes into account the analysis of information about the activities of construction companies based on engineering and the concept of open sources, which is used to create a list of alternatives in the task of choosing rational strategies for the diversification of companies and allows expanding their management capabilities;

• improved information technology for evaluating and choosing diversification strategies of construction companies in conditions of uncertainty, which is distinguished by taking into account the technical and economic parameters of construction and the advantages of participants in the construction process and allows expanding management capabilities and rationalizing the choice of diversification strategies of construction companies.

• received further development of the conceptual presentation of the structural model of the organizational environment of construction companies, which takes into account the diversification of their activities and is distinguished by the fact that it organically combines the entire range of activities of project-oriented companies in conditions of uncertainty.

The first chapter describes the peculiarities of the diversification of construction enterprises, the main concepts, types of diversification, and the possible effects of the diversification of activities. The relevance of the development of the construction industry and the diversification of the activities of construction companies are substantiated. The possible consequences after the diversification of the construction industry are characterized by conditions of uncertainty and risk: more effective use of human resources, equipment and technologies, risk reduction, intensification of post-war reconstruction (in Ukraine), an increase in the level of development of infrastructure, manufacturing and housing construction in countries with rapid economic growth (especially in the People's Republic of China).

The well-known methods of multi-criteria decision-making are described, which motivate the application of decision-making strategies in the conditions of formation and evaluation regarding the diversification of the activities of the construction enterprise. It is indicated that since diversification strategies can have a significant number of evaluation criteria due to the presence of many stakeholders, financial needs, diversity and heterogeneity of the industry, the application of new or modification of known methods of multi-criteria decision-making can help solve the task of evaluating diversification strategies of

construction enterprises. Since the task of assessing the diversification strategies of construction companies is complex and has many influencing factors, it is essential to develop information technology that would significantly simplify the work of the construction company's decision-maker or management team.

In the second chapter, it is established that in the uncertain conditions in which construction companies operate, it is necessary to change the perception of the organizational environment of the construction company, which consists of the internal and external environment and task environment. These components of the same organizational environment were described with the caveat of the need to include a separate component corresponding to diversification tasks. Thus, because of the study, the conceptual presentation of the structural model of the organizational environment of construction companies, which takes into account the diversification of their activities and is distinguished by the fact that it organically combines the entire range of activities of companies in conditions of uncertainty, received further development.

A formal presentation of construction technology and the task of choosing a construction technology is described. The choice of construction technology, in combination with the analysis of the competitive market and the analysis of technical and economic requirements for the task of diversification, makes it possible to thoroughly approach the formation of diversification strategies for the construction company. The concept of the formation of diversification strategies of construction companies is described, considering the principles of engineering, which takes into account six main stages from the formation of requirements for diversification activities to the evaluation of the results of implementing the diversification strategy in construction projects. A list of advantages from the formation of diversification strategies based on new principles is described: the ability to reflect complex diversification processes and management processes of construction companies in conditions of uncertainty, taking into account engineering; the ability to create, evaluate and implement diversification strategies and use a scientifically based selection of optimal diversification strategies that are

aimed at increasing the profits of the construction company, increasing the credibility of the analysis of diversification data and the competitive market, using the concept of open data, etc.

The third chapter describes the general task of the multi-criteria selection of diversification strategies for construction companies, which can be used in conditions of uncertainty when the external environment influences the company's activities: technological changes, political, economic, and other factors. The model for choosing rational diversification strategies of construction companies based on an expert assessment of construction's technical and economic parameters is described, which considers the most significant indicators and the advantages of participants in the construction process. These advantages and the features of diversification strategies are included in the indicators of the diversification center, which should be created in the construction company. The method of evaluating diversification strategies of construction companies has been improved, which is distinguished by considering changes in the structure of companies' organizational environments and allowing them to increase their management efficiency. This method is based on expert assessment and considers the opinions of all participants in the construction process: owners, developers, investors, general contractors, and designers. The method described for evaluating the diversification strategies of construction companies was verified using the example of a construction company in the People's Republic of China.

The fourth chapter describes an improved information technology for evaluating and choosing diversification strategies of construction companies under conditions of uncertainty, which is distinguished by considering the technical and economic parameters of construction and the advantages of participants in the construction process and allows expansion management capabilities and rationalize the choice of diversification strategies of construction companies.

The practical significance of the obtained results is that the developed methods, models and information technology for the formation, evaluation, and selection of diversification strategies of construction enterprises are an essential

step in developing a theoretical and practical basis for ensuring sustainability and profitability of construction companies. The resulting tool is practically important for construction companies, holdings, and the construction industry. In the long term, using the developed methods and models will positively impact the development of the state's building industry. The main provisions and results of the research were implemented and applied in the activities of Yancheng Polytechnic College.

The obtained results, theoretically and practically, serve as a basis for further scientific and applied research aimed at improving various aspects of the management of construction companies. Ensuring the sustainability of the development of construction companies and the organization of their diversification activities are the key signs of the sustainability of the development of the country's construction industry.

Keywords: project management, information technology, construction enterprise, project management, mathematical model, diversification, decision-making, assessment task, choice task, information management, project-oriented company, business process.

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АНОТАЦІЯ

Лі Юаньюань. Інформаційна технологія оцінювання стратегій диверсифікації будівельних підприємств в умовах невизначеності – *Кваліфікаційна наукова праця на правах рукопису.*

Дисертація на здобуття наукового ступеня доктора філософії за спеціальністю 126 «Інформаційні системи та технології» – Київський національний університет імені Тараса Шевченка, Київ, 2024.

Зміст анотації. Дисертація присвячена побудові методів, моделей та інформаційної технології для формування, оцінювання та вибору стратегій диверсифікації будівельних підприємтсв в умовах невизначеності. Побудовані методи та моделі можуть бути використані для вирішення актуального науково-практичного завдання підвищення ефективності управління та прибутковості будівельних підприємств в умовах недостатності інформації під дією впливу технологічних, економічних, політичних, соціальних та інших зовнішніх факторів, передбачити наслідки впливу яких неможливо.

Одним з методів, які дозволяють вирішити цю задачу є диверсифікація діяльності будівельних підприємств. Актуальність задачі диверсифікації для будівельних підприємств базується на кількох ключових чинниках. Першим чинником є затребуваність розвитку будівельної галузі в умовах швидкого економічного зростання у країнах, які мають сприятливі для цього умови. Швидке економічне зростання проявляється у збільшенні ВВП країни, покращенні життєвого рівня населення, збільшенні зайнятості, розвитку інфраструктури, збільшенні обсягів торгівлі та іноземних інвестицій тощо. Китайська народна республіка відома своїм вражаючим економічним зростанням у протягом останніх десятиліть. Це досягнення було можливим завдяки швидкому темпу індустріалізації, експортно-орієнтованому підходу до економіки та широкому впровадженню реформ. Диверсифікація може допомогти підприємствам використовувати свої ресурси, такі як людські ресурси, обладнання та технології, більш ефективно, розширюючи їх застосування на різних ринках або в різних галузях. Диверсифікація може дати будівельному підприємству конкурентну перевагу, забезпечуючи йому більш гнучкий та адаптивний бізнес-підхід, що дозволить розширити асортимент послуг для задоволення потреб різних клієнтів. Проте будівельна галузь відома своєю високою вразливістю до економічних коливань та змін у ситуації на ринку, змін в економічній ситуації, політичних турбулентностях та конфліктах.

Саме тому в цих умовах виникає ряд невирішених питань, а саме: немає достатніх обгрунтованих досліджень щодо врахування в організаційній структурі компанії окремого диверсифікаційного центру, діяльність якого спрямована на формування, оцінювання та вибору стратегій диверсифікації компанії. Також у випадку горизонтальної інтеграції не з’ясовано вплив вибору технологій будівництва та вибір значень техніко-економічних параметрів будівництва на вибір стратегії диверсифікації будівельного підприємства. Немає достатньо надійних методів оцінювання та вибору

стратегій диверсифікації, які б давали можливість підвищити прибутковість будівельних компаній.

Створення методів та моделей формування, оцінювання та вибору стратегій диверсифікації будівельних підприємтв дозволить практично підвищити продуктивність та прибутковість будівельних підприємств, а також розширяє теоретичні та практичні напрацювання в даному напрямку.

Отже, в даній дисертаційній роботі вирішується важливе завдання, а саме: розроблення моделей, методів та інформаційної технології для вибору раціональних стратегій диверсифікації будівельних компаній, що відрізняється врахуванням змін у структурі організаційних середовищ компаній і органічно поєднує в собі весь спектр діяльності компаній в умовах невизначеності (наукова складова). Також вирішується задача автоматизації оцінювання та вибору стратегій диверсифікації. Розроблені методи та моделі інтегруються у відповідній інформаційній технології (практична складова).

Об’єктом дослідження є процеси, які пов’язані з оцінюванням та прийняття рішень щодо вибору стратегій диверсифікацій будівельних компаній в умовах невизначеності.

Предметом дослідження є методи, моделі та інформаційна технологія управління діяльністю будівельних компаній в частині формування, оцінювання та вибору раціональних стратегій диверсифікацій в умовах невизначеності.

Методи дослідження. Проведені дослідження базуються на методах представлення і обробки знань, методах оцінювання, моніторингу діяльності будівельних компанії та їх організаційних структур, об'єктно-орієнтованого програмування, управління проєктами.

Метою дослідження є розроблення методів, моделей та інформаційної технології оцінювання та вибору стратегій диверсифікацій будівельних компаній для управління їх діяльністю в умовах невизначеності.

Наукова новизна отриманих результатів:

- вперше описано модель вибору раціональних стратегій диверсифікації будівельних компаній на основі експертного оцінювання техніко-економічних параметрів будівництва, який враховує найбільш значимі показники і дозволяє врахувати переваги учасників будівельного процесу.
- удосконалено метод оцінювання стратегій диверсифікації будівельних компаній, що відрізняється врахуванням змін у структурі організаційних середовищ компаній, що характерно для умов невизначеності і дозволяє підвищити ефективність управління ними.
- удосконалено метод формування стратегій диверсифікації, що враховує аналіз інформації про діяльність будівельних компаній на основі інжинірингу та концепції відкритих джерел, який використовується для створення переліку альтернатив в задачі вибору раціональних стратегій диверсифікації компаній і дозволяє розширити можливості управління ними;
- удосконалено інформаційну технологію оцінювання та вибору стратегій диверсифікації будівельних компаній в умовах невизначеності, що відрізняється врахуванням техніко-економічних параметрів будівництва та переваг учасників будівельного процесу і дозволяє розширити можливості управління та раціоналізувати вибір стратегій диверсифікації будівельних компаній.
- отримало подальший розвиток концептуальне представлення структурної моделі організаційного середовища будівельних компаній, що враховує диверсифікацію їх діяльності і відрізняється тим, що органічно поєднує в собі весь спектр діяльності проєктно-орієнтованих компаній в умовах невизначеності.

У першому розділі описано особливості диверсифікації діяльності будівельних підприємств, основні поняття, види диверсифікації та можливий ефект від проведення диверсифікації діяльності. Обгрунтовано актуальність розвитку будівельної галузі та проведення диверсифікації діяльності будівельних компаній. Охарактеризовано можливі наслідки після

прооведення диверсифікації будівельних підприсмств, зокрема в умовах невизначеності і ризику: ефективніше використання людських ресурсів, обладнання та технологій, зниження ризиків, інтенсифікація поствоєнної відбудови (зокрема в Україні), зростання рівня розвитку інфраструктури, мануфактурного та житлового будівництва галузі в країнах зі швидким економічним зростанням (зокрема в Китайській народній республіці).

Описано відомі методи багатокритеріального прийняття рішень, які модуить бути застосовані в умовах формування та оцінювання стратегій прийняття рішень щодо диверсифікації діяльності будівельного підприємства. Вказано, що оскільки стратегії диверсифікації можуть мати значне число критеріїв оцінювання через наявність багатьох стейкхолдерів, фінансових потреб, різноманітності та необнорідності галузі, то застосування нових або модифікація відомих методів багаторитеріального прийняття рішень може допомогти вирішити задачу оцінювання стратегій диверсифікації будівельних підприємств. Оскільки задача оцінювання стратегій диверсифікації будівельних підприємтв є складною і має багато факторів впливу, то для цього актуальним є розроблення інформаційної технології, яка б суттєво спростило роботу особі, яка приймає рішення, або керівному складу будівельної компанії.

В другому розділі встановлено, що в умовах невизначеності, в яких функціонують будівельні компанії, потрібно змінити уявлення про організаційне середовище будівельної компанії, яке складається з внутрішнього, зовнішнього середовища та середовища завдань. Ці складові одного організаційного середовища були описані з вархуванням необхідності включення окремої складової, що відповідає диверсифікаційним задачам. Таким чином в результаті дослідження отримало подальший розвиток концептуальне представлення структурної моделі організаційного середовища будівельних компаній, що враховує диверсифікацію їх діяльності і відрізняється тим, що органічно поєднує в собі весь спектр діяльності компаній в умовах невизначеності.

Описано формальне представлення технології будівництва та задачі вибору технології будівництва. Вказано, що вибір технології будівництва в комплексі з аналізом конкурентного ринку та аналізом техніко-економічних вимог для задачі диверсифікації дає можливість грунтовно підійти до формування стратегій диверсифікації будівельно компанії. Описана концепція формування стратегій диверсифікації будівельних компаній з врахуванням принципів інжинірингу, що враховує шість основних етапів від формування вимог до диверсифікаційної діяльності до оцінки результатів впровадження стратегії диверсифікації в будівельних проєкт. Описано перелік переваг від формування стратегій диверсифікації на нових принципах: наявність можливості відображати складні диверсифікаційні процеси та процеси управління будівельними компаніями в умовах невизначеності з врахуванням інжинірингу; можливість створювати, оцінювати та впроваджувати стратегії диверсифікації та використовувати науково-обгрунтований вибір оптимальних стратегій диверсифікації, які спрямовані на підвищення прибутків будівельної компанії, підвищення достовірності аналізу диверсифікаційних даних та конкурентного ринку, використовуючи концепцію відкритих даних тощо.

В третьому розділі описано загальна задача багатокритеріального ивбору стратегій диверсифікації будівельних компаній, яка може використовуватись в умовах невизначеності, коли на діяльність компанії здійснює вплив зовнішнє середовище: технологічні зміни, політичні, економічні та інші фактори. Описано модель вибору раціональних стратегій диверсифікації будівельних компаній на основі експертного оцінювання техніко-економічних параметрів будівництва, який враховує найбільш значимі показники і дозволяє врахувати переваги учасників будівельного процесу. Ці переваги, а також особливості стратегій диверсифікації закладаються в показники центром диверсифікації, що має бути створено в будівельній компанії. Удосконалено метод оцінювання стратегій диверсифікації будівельних компаній, що відрізняється врахуванням змін у

структурі організаційних середовищ компаній і дозволяє підвищити ефективність управління ними. Цей метод заснований на експертному оцінюванні та передбачає врахування думок всіх учасників будівельного процесу: власників, забудовників, інвесторів, генпідрядників та генпроектувальників. Верифіковано описаний метод оцінювання стратегій диверсифікації будівельних компаній на прикладі діяльності будівельної компанії у Китайській народній республіці.

У четвертому розділі описано удосконалену інформаційну технологію оцінювання та вибору стратегій диверсифікації будівельних компаній в умовах невизначеності, що відрізняється врахуванням техніко-економічних параметрів будівництва та переваг учасників будівельного процесу і дозволяє розширити можливості управління та раціоналізувати вибір стратегій диверсифікації будівельних компаній.

Практичне значення одержаних результатів полягає у тому, що розроблені методи, моделі та інформаційна технологія формування, оцінювання та вибору стратегій диверсифікації будівельних підприємств є важливим кроком у розвитку теоретичної та практичної бази для забезпечення сталості та прибутковості будівельних компаній. Отриманий інструмент є важливим практично для будівельних компаній, холдингів, а також для будівельної галузі в цілому. В довготривалій перспективі використання розроблених методів та моделей дасть позитивний вплив на розвиток юудівельної галузі держави в цілому. Основні результати роботи впроваджено в діяльності Yancheng Polytecnic College.

Отримані результати, як у теоретичному, так і практичному плані, служать основою для подальших науково-прикладних досліджень, спрямованих на удосконалення та покращення різних аспектів управління будівельними компаніями. Забезпечення сталості розвитку будівельних компаній, організація їх диверсифікаційної діяльності є в основі ключових ознак сталості розвитку будівельної галузі країни.

Ключові слова: управління проєктами, інформаційна технологія, будівельне підприємтсво, управління проєктами, математична модель, диверсифікація, прийняття рішень, задача оцінювання, задача вибору, інформаційний менеджмент, проєктно-орієнтована компанія, бізнес-процес.

СПИСОК ПУБЛІКАЦІЙ ЗДОБУВАЧА ЗА ТЕМОЮ ДИСЕРТАЦІЇ

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CONTENT

INTRODUCTION

The relevance of the task of diversification for construction enterprises is based on several key factors. The first factor is the demand for developing the construction industry in conditions of rapid economic growth in countries with favorable conditions. Rapid economic growth is manifested in an increase in the country's GDP, an improvement in the population's standard of living, an increase in employment, the development of infrastructure, an increase in the volume of trade and foreign investment, etc. The People's Republic of China is known for its impressive economic growth over the past decades. This achievement was possible due to the rapid pace of industrialization, an export-oriented approach to the economy, and the comprehensive implementation of reforms. Diversification can help businesses use their resources, such as human resources, equipment, and technology, more efficiently by expanding their applications in different markets or industries. Diversification can give a construction company a competitive advantage, providing it with a more flexible and adaptive business approach that will expand the range of services to meet the needs of different customers. However, the construction industry is known for its high vulnerability to economic fluctuations and changes in the market situation, economic situation, political turbulence, and conflicts.

That is why, in these conditions, several unresolved issues arise. More studies need to be conducted regarding including a separate diversification center in the company's organizational structure, whose activities aim to form, evaluate, and choose the company's diversification strategies. Also, in the case of horizontal integration, the influence of the choice of construction technologies and the choice of the values of the technical and economic parameters of construction on the choice of the diversification strategy of the construction enterprise has yet to be clarified. There needs to be sufficiently reliable methods of evaluating and selecting diversification strategies that would provide an opportunity to increase the profitability of construction companies.

Creating methods and models for forming, evaluating, and selecting diversification strategies for construction enterprises will increase their productivity and profitability and expand theoretical and practical developments in this direction.

Therefore, this dissertation solves an important task, namely, the development of models, methods and information technology for choosing rational strategies for the diversification of construction companies, which is characterized by taking into account changes in the structure of organizational environments of companies and organically combines the entire range of activities of companies in conditions of uncertainty (scientific component). Automating the evaluation and selection of diversification strategies is also solved. The developed methods and models are integrated into the relevant information technology (practical component).

The dissertation work was carried out at the Faculty of Information Technologies of Taras Shevchenko National University of Kyiv following the plan of research works of Taras Shevchenko National University of Kyiv, in particular the topic "Information technologies of analysis and forecasting of processes, invariant to the subject area", No. 0123U101621.

The object of the study is the processes related to the evaluation and decision-making regarding the choice of diversification strategies for construction companies in uncertain conditions.

The subject of the research is the methods, models and information technology of managing the activities of construction companies in terms of forming, evaluating and choosing rational diversification strategies in conditions of uncertainty.

Research methods. The research is based on knowledge presentation and processing methods, evaluation methods, monitoring of construction companies and their organizational structures, object-oriented programming, project management.

The study aims to develop methods, models, and information technology for evaluating and choosing diversification strategies for construction companies to manage their activities in uncertain conditions.

To achieve the goal, the following tasks must be solved:

1. To analyze the peculiarities of the diversification of the activities of construction enterprises and the relevance of the implementation and evaluation of diversification strategies in conditions of uncertainty.

2. To build a structural model of the organizational environment of construction companies that considers diversification.

3. To describe the concept of forming diversification strategies for construction companies, considering engineering principles.

4. Describe the general task of the multi-criteria selection of diversification strategies for construction companies, which can be used in uncertain conditions. To build a method of evaluating diversification strategies and a model for choosing rational diversification strategies of construction companies.

5. Descriptors of improved information technology for evaluating and choosing diversification strategies of construction companies in conditions of uncertainty, which would affect the technical and economic parameters of construction and the benefits of participants in the construction process.

The scientific novelty of the obtained results:

- for the first time, a model for choosing rational diversification strategies of construction companies is described based on an expert assessment of the technical and economic parameters of construction, which takes into account the most significant indicators and allows taking into account the advantages of participants in the construction process;
- the method of evaluating diversification strategies of construction companies has been improved, which is distinguished by taking into account changes in the structure of organizational environments of companies, which is

characteristic of conditions of uncertainty and allows to increase the efficiency of their management;

- the method of forming diversification strategies has been improved, which takes into account the analysis of information about the activities of construction companies based on engineering and the concept of open sources, which is used to create a list of alternatives in the task of choosing rational strategies for the diversification of companies and allows expanding their management capabilities;
- improved information technology for evaluating and choosing diversification strategies of construction companies in conditions of uncertainty, which is distinguished by considering the technical and economic parameters of construction and the advantages of participants in the construction process and allows expanding management capabilities and rationalizing the choice of diversification strategies of construction companies;
- received further development of the conceptual presentation of the structural model of the organizational environment of construction companies, which considers the diversification of their activities and is distinguished by the fact that it organically combines the entire range of activities of project-oriented companies in conditions of uncertainty.

The first chapter describes the peculiarities of the diversification of construction enterprises, the main concepts, types of diversification, and the possible effects of the diversification of activities. The relevance of the development of the construction industry and the diversification of the activities of construction companies are substantiated. The possible consequences after the diversification of the construction industry are characterized, in particular, by conditions of uncertainty and risk: more effective use of human resources, equipment and technologies, risk reduction, intensification of post-war reconstruction (in particular in Ukraine), an increase in the level of development of

infrastructure, manufacturing and housing construction in countries with rapid economic growth (especially in the People's Republic of China). The well-known methods of multi-criteria decision-making are also described, which motivate the application of decision-making strategies regarding the diversification of the activities of the construction enterprise in the conditions of formation and evaluation. It is indicated that since diversification strategies can have a significant number of evaluation criteria due to the presence of many stakeholders, financial needs, diversity and heterogeneity of the industry, the application of new or modification of known methods of multi-criteria decision-making can help solve the task of evaluating diversification strategies of construction enterprises. Since assessing the diversification strategies of construction companies is complex and has many influencing factors, it is essential to develop information technology that would significantly simplify the work of the construction company's decision-maker or management team.

In the second chapter, it is established that in the uncertain conditions in which construction companies operate, it is necessary to change the perception of the organizational environment of the construction company, which consists of the internal and external environment and task environment. These components of the same organizational environment were described with the caveat of the need to include a separate component corresponding to diversification tasks. Thus, because of the study, the conceptual presentation of the structural model of the organizational environment of construction companies, which takes into account the diversification of their activities and is distinguished by the fact that it organically combines the entire range of activities of companies in conditions of uncertainty, received further development.

A formal presentation of construction technology and the task of choosing a construction technology is described. The choice of construction technology, in combination with the analysis of the competitive market and the analysis of technical and economic requirements for the task of diversification, makes it

possible to thoroughly approach the formation of diversification strategies for the construction company. The concept of the formation of diversification strategies of construction companies is described, considering the principles of engineering, which takes into account six main stages from the formation of requirements for diversification activities to the evaluation of the results of implementing the diversification strategy in construction projects. A list of advantages from the formation of diversification strategies based on new principles is described: the ability to reflect complex diversification processes and management processes of construction companies in conditions of uncertainty, taking into account engineering; the ability to create, evaluate and implement diversification strategies and use a scientifically based selection of optimal diversification strategies that are aimed at increasing the profits of the construction company, increasing the credibility of the analysis of diversification data and the competitive market, using the concept of open data, etc.

The third chapter describes the general task of the multi-criteria selection of diversification strategies for construction companies, which can be used in conditions of uncertainty when the external environment influences the company's activities: technological changes, political, economic, and other factors. The model for choosing rational diversification strategies of construction companies based on an expert assessment of construction's technical and economic parameters is described, which considers the most significant indicators and the advantages of participants in the construction process. These advantages and the features of diversification strategies are included in the indicators of the diversification center, which should be created in the construction company. The method of evaluating diversification strategies of construction companies has been improved, which is distinguished by considering changes in the structure of companies' organizational environments and allowing them to increase their management efficiency. This method is based on expert assessment and considers the opinions of all participants in the construction process: owners, developers, investors, general contractors and

designers. The method described for evaluating the diversification strategies of construction companies was verified using the example of a construction company in the People's Republic of China.

The fourth chapter describes an improved information technology for evaluating and choosing diversification strategies of construction companies under conditions of uncertainty, which is distinguished by taking into account the technical and economic parameters of construction and the advantages of participants in the construction process and allows expansion management capabilities and rationalize the choice of diversification strategies of construction companies.

The practical significance of the obtained results is that the developed methods, models and information technology for the formation, evaluation and selection of diversification strategies of construction enterprises are an essential step in developing a theoretical and practical basis for ensuring sustainability and profitability of construction companies. The resulting tool is practically important for construction companies, holdings, and the construction industry. In the long term, the use of the developed methods and models will positively impact the development of the country's construction industry. The main provisions and results of the research were implemented and applied in the activities of Yancheng Polytechnic College.

The obtained results, theoretically and practically, serve as a basis for further scientific and applied research aimed at improving various aspects of the management of construction companies. Ensuring the sustainability of the development of construction companies and the organization of their diversification activities are the key signs of the sustainability of the development of the country's construction industry. The author published the work's primary results in the following publications [1-11].

Personal contribution of the acquirer.

The applicant personally received the main provisions and results of the dissertation work. The work [1] describes the task of diversification as a component of the adaptive management of construction companies. The work [2] describes developed multi-criterion methods for selecting rational strategies for diversifying building enterprises under uncertainty. The problem of choosing a diversification strategy for a building enterprise in risk conditions is described in [3]. The work [4] describes the method of evaluating formed diversification strategies and models for choosing a rational strategy for a construction enterprise. Work [5] describes the problem of choosing diversification strategies. Other works [6-11] describe some components of the dissertation research, which were presented at international conferences. The work [6] was published in the edition indexed in the Scopus scientometric database.

Approval of the results of the dissertation. The main results of the work were reported, discussed, and received a positive evaluation at international conferences "Information technologies and interactions", Kyiv (2018, 2019), "Project Management in the Development of Society", Kyiv (2019), "Information Modeling Technologies, Systems and Complexes", Chernivtsi (2019), "Technology Development Management", Kyiv (2020), IEEE conference "Smart Information Systems and Technologies" (SIST-2021), Astana, Republic of Kazakhstan.

Publications. Based on the dissertation materials, 11 scientific works have been published, including: 4 scientific articles in specialized publications of Ukraine, 1 article in a publication that is not included in the list of the Ministry of Education and Culture, 6 materials of international conferences, one of them in a publication that is indexed by the Scopus database. The main results of the work were obtained by the author personally. Some of the scientific works published in co-authorship, the dissertation research describes those provisions resulting from the author's work.

Structure and scope of work. The dissertation consists of an introduction, four chapters, chapter conclusions, main conclusions, a list of references and

appendices. The total volume of the dissertation is 140 pages, including 12 figures, 6 tables, a bibliography of 95 titles and 2 appendices.

CHAPTER 1. THE PROBLEM OF DIVERSIFICATION OF ENTERPRISES UNDER UNCERTAINTY

1.1. Application of diversification approaches to increase the efficiency of project-oriented construction enterprises

Scientific and technical development, increased competition between manufacturers and a reduction in the life cycle of products are a consequence of the variability of the vector of economic development. In order to accelerate growth rates and activate scientific and technical progress in the field of production, it is necessary to adapt the enterprises of the field to external conditions, which are often uncertain. One of the approaches that allows an increase in the efficiency of the enterprise in such conditions is the implementation of several measures to manage its activities to adapt the enterprise to the variability of external conditions. One of the most important measures in this direction is forming a rational strategy for the company's activities. The theory of adaptive strategic management [1] can answer how to form an effective strategy and evaluate its effect from implementation. In fig. 1.1 depicts the general scheme of the enterprise's activity in conditions of uncertainty and risk.

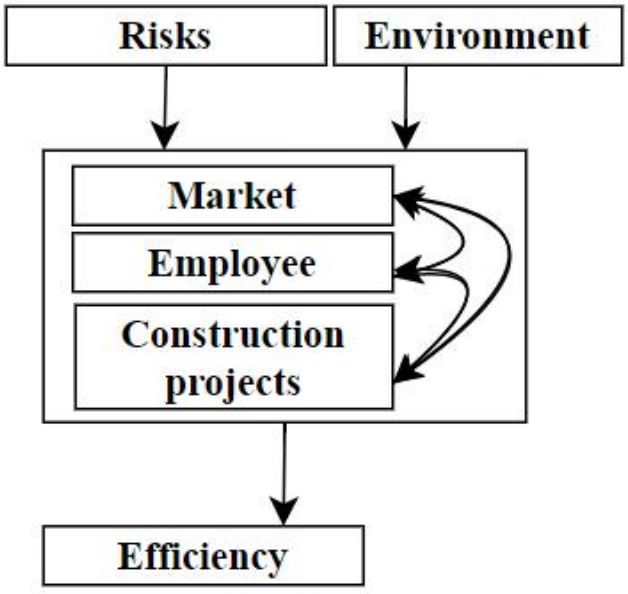

Figure 1.1. – Scheme of operation of the enterprise under risk conditions

As we can see from Fig. 1.1. the efficiency of the enterprise is ensured by the unity of the equipment capabilities, the efficiency of the personnel, the opportunities to enter the market and the quality of the manufactured products. The balance of this system is influenced by the external environment, particularly the risks accompanying the activity a priori, especially in transitional economies. The issue of ensuring the effective operation of the enterprise can be solved by forming a rational activity strategy that correlates with the goals of the enterprise and is part of adaptive strategic management in general. In economic instability, the impact of risks is significantly intensified as uncertainty increases. Therefore, the creation of an enterprise activity strategy is often associated with the creation of adequate conditions for the diversification of this activity.

This paragraph examines the main concepts and principles of diversification of enterprise activity as a component of adaptive management and analyzes the latest research in this direction.

The diversification of the enterprise is one of the critical elements of the effectiveness of its adaptive management. The introduction of diversification is explained by the growth of the dynamics of the economy, the creation and activation of new markets, permanent crisis phenomena in the economy, and changes in the demand for products. Diversification of the company's activities and adaptive management allows you to profit in new markets if there are losses in the primary market.

Businesses that use diversification are competitive and more profitable than other businesses. This is because diversified enterprises increase the names of goods and services and penetrate new fields of activity.

Analyzing the diversification approaches of enterprises, we can conclude that the construction of diversification strategies in each country (Ukraine, China, EU countries) has some differences and peculiarities. This is due to legislation and traditional business management approaches developed in each country separately.

In general, diversification is divided into two components: diversification of activities and diversification of production. In general, these two components can

be combined. In addition, we will consider a unique approach to diversification since we are interested in diversifying construction enterprises. Diversification of the activities of enterprises, in particular the construction industry, leads to the growth of the company's profits in the long term and reduces risks.

However, the diversification of the enterprise is always associated with the risk of uncertainty. The company has not worked in the new market, needs to learn its features and cannot effectively calculate profits and losses. This problem is eliminated by a comprehensive approach to diversification, considering adaptive strategic management, which involves the analysis of possible markets for the diversification of activities. In addition, to create effective diversification strategies, it is necessary to forecast the company's activity based on its activity indicators [12-17].

Also, strategic management of enterprise activities requires the application of new concepts of project and program management [18-23].

Works [24-26] describe the features of enterprises' investment and diversification activities.

In works [27, 28], four main strategies of enterprise development were formed: market penetration (market penetration), development of new products (new product development), market development (market development), and diversification (diversification). Diversification is the most challenging strategy because it requires new knowledge, skills, resources, tools and technologies from the enterprise, allowing it to compete with other enterprises in a new market.

In work [29] it is indicated that the enterprise can choose diversification of activities only when there are no other opportunities for growth. It is proposed to carry out tests to determine the effectiveness of diversification of activities:

1. The chosen market should be attractive for the consumer.

2. The cost of diversification must be acceptable for the enterprise.

3. The new market should fuel the enterprise to obtain a competitive advantage.

So, diversification is a process of development of the company's activity, which is associated with an increase in the range of types and penetration into new areas of activity, development of new productions, and expansion of the range of goods, which includes not only the diversification of product groups but also the spread of entrepreneurial activity to new and related to the main activities of the firm [30]. The diversification strategy represents the main direction of the company's development based on internal demand and opportunities for this development, taking into account the influence of external factors on this process in order to achieve fundamentally new or adjusted goals within the limits of legislative aspects and peculiarities of diversification activities in general. Creating a strategy should be subordinated to the goals of adaptive strategic management of the enterprise as a whole.

The main principles for creating enterprise strategies, in particular for diversification, are:

1. The strategy should embody the general goals of the enterprise within the goals of adaptive strategic management.

2. The strategy should offer several options for development, depending on the circumstances, which makes it flexible and more adaptable to the adverse influence of external factors.

3. The strategy should be open to periodic adjustments. This is because some development options may be hidden in uncertain conditions due to insufficient information. When reducing uncertainty, adjusting the already active strategy is important to obtain a more significant economic effect.

4. The strategy should comprehensively reflect all the enterprise's peculiarities and types of activity, particularly in terms of diversification.

In addition to the company's diversification strategy, financial, investment, and marketing strategies are distinguished. Also, by the level of globality, it is possible to distinguish a key strategy and local strategies that support the development of the key in specific directions.

The process of creating a diversification strategy is complex and multi-level:

Level 1. Outline of the global goal of the enterprise.

Level 2. A thorough study of the impact of the external environment on the company's activities.

Level 3. Carrying out a SWOT analysis.

Level 4. Creation of a list of strategic goals of the enterprise, which are connected by a common goal.

Level 5. Evaluation of strategic alternatives according to several criteria: considering the influence of the external environment, effectiveness, and balance with the company's capabilities and resource potential.

Level 6. Identify qualitative and quantitative KPI indicators of those strategies selected for implementation. Formation of a roadmap for the development of strategies.

Level 7. Monitoring the implementation of diversification strategies by the road map. If necessary, adjust strategies to be consistent with the principles of adaptive strategic management.

The formation of a diversification strategy, according to the assumption, is the basis for increasing the efficiency of the enterprise, especially in the conditions of a transitional economy. Economic efficiency means achieving planned results by the enterprise for a certain period by consuming resources (material, human) that do not exceed previously established levels. Thus, to achieve effective activity, it is necessary to clearly follow the roadmap for developing the company's strategies and KPI values. That is, the strategies of the enterprise must also be effective, which means that they must be carried out within the framework of the road map in a precise time, with the achievement of the appropriate levels of KPI within the general principles of adaptive strategic management, which are established at the enterprise and which is ultimately expressed in the corresponding economic effect Δ. Economic efficiency is generally expressed by the ratio of the economic effect to the expenditure of resources for its provision R:

$$E = \frac{\Delta}{R}, \tag{1.1}$$

where E – economic efficiency of the enterprise.

Let us consider the peculiarities of the diversification of construction companies, which is relevant due to the significant development of the construction industry in the last decade in Ukraine, China and the world. In general, in order to create an effective system of adaptive strategic management of the construction enterprise itself, in particular, in terms of diversification of activities, the following tasks must be completed:

1. Analyze construction enterprises and their classification of the application of diversification strategies.

2. Investigate construction enterprise diversification strategies, considering risk and financial effects.

3. To propose more profitable strategies for the diversification of construction enterprises.

The marketing strategy supports the diversification strategy in adaptive management. This strategy is manifested in increasing the name and types of goods and services, improving service, strengthening consumer demand and attracting new consumers through advertising. For example, let a construction company engage in residential construction. To increase the demand for its main products, the company can engage in interior design, production and sale of furniture, windows, doors, etc. All this can be offered to potential customers to increase profits.

However, diversification can refer to products and services unrelated to the primary production. This type of diversification is complicated. However, in the case of its successful implementation, the enterprise significantly reduces the risks associated with crisis phenomena in the primary industry. To implement this type of diversification, the enterprise needs to create new connections with consumers and partners, form a new system of sales of services and goods, conduct effective marketing, and gain experience in a new market. This requires time and considerable human and financial resources.

Diversification as a complex process is a combination of the process of creating new goods and services and entering new markets. Goods and services may be entirely new for the core business. A strategy that new activities are expensive and risky. So, diversification involves entering new markets unrelated to the main activity. This contributes to the development of inter-industry ties, which positively affects the economy of the region or the country as a whole. In general, diversification is used to increase economic benefits and reduce risks in economic instability and uncertainty conditions.

The classic view of diversification strategies is considered in the work [31]. The construction of diversification strategies largely depends on the combination of competencies and capabilities of the enterprise to carry out diversification with the desire to increase the variety of goods and services.

The system of indicators that determine the enterprise's ability to implement diversification is described in [32]:

1. Specialization Ratio (SR): The proportion of a firm's annual revenues to its core business in a year.

2. Related Ratio (RR): The proportion of a firm's annual revenues attributable to its most significant group of related enterprises.

3. Contiguous Core Resource Ratio (CR): The proportion of a firm's annual revenues attributable to its most prominent business group that shares or uses the same common skills or resources.

4. Vertical Ratio (VR): The proportion of a firm's annual revenues attributable to its largest product group.

According to the definitions, SR indicates the state of diversity used in the economy, RR and CR characterize horizontal diversification strategies, and VR is for vertical strategies.

According to the concept described in [33], diversification involves identifying the type of activity (product) in which the company's competitive advantages can be most effectively implemented. The company engages in diversification strategies if it is necessary to reduce risk or to obtain profits in other

industries. For Ukrainian construction companies, the main reason for implementing diversification strategies is the economic crisis of recent years. These crisis phenomena threaten stable profits and fulfilling obligations to customers and partners.

In the unstable Ukrainian economy, diversification of activities is an effective way to reduce risks. Another classification of diversification strategies is as follows:

1. Assortment diversification. When a product is produced, a service is provided with significant differences from other market positions.

2. Conglomerate diversification. Investing in a market utterly unrelated to the primary production.

3. Chain diversification. It involves the involvement of suppliers, carriers, and other companies related to the main activity of the company's structure.

The generally accepted classification of enterprise strategies includes dominant vertical, limited, unrelated, related, and conglomerate strategies.

Related diversification involves the involvement of factors already existing in the primary production. Such factors include personnel, sales channels, technology, suppliers, marketing systems, management methods, etc. The related diversification can be strong or weak. A well-organized strategy of related diversification has a positive effect on all strategies of the construction company. This type of diversification increases the competitiveness of essential goods and services and reduces production costs thanks to the introduction of new technologies.

An unrelated strategy involves creating a new product or service complementary to the main product or service. A conglomerate strategy involves the creation of a new product that is not related to the main product and is aimed at a new consumer. Conglomerate diversification is more complicated. Its implementation is a costly and risky process. On the other hand, if the enterprise produces only one type of goods, this is a factor of additional risks.

Another classification distinguishes the following types of diversification:

- vertical diversification consists of the fact that the enterprise produces goods that are related to the primary goods. In this case, the enterprise creates goods and services independently, without buying them from third-party enterprises;

- horizontal diversification involves the release of goods that are not technologically related to the main goods but, in general, may be attractive to the main customers of the enterprise. In this case, enterprises can unite and produce goods that will be in demand among a specific group of customers;

- conglomerate diversification involves the creation of goods and services that are entirely unrelated to the primary goods and services. Customers of such goods and services can be completely different consumers. The sales market for such goods differs from the main one. In this case, the company's activity extends to new industries to reduce risk, increase profits, and open new markets.

The work [34] defines the following types of diversification processes:

1. Concentric (vertical) – the enterprise produces goods related to the existing goods of the firm in terms of technology and marketing. The advantages of this type of diversification are guarantees for the supply of resources, the availability of reliable product sales channels, and the stability of business relations at the enterprise. The disadvantages of this type of diversification are reduced competition, a limited sales market, significant production costs, etc.

2. Horizontal diversification - expansion of one's range of products with products that are not related to what is produced but create the interest of existing customers. Horizontal diversification involves the development of new markets and areas of business that satisfy the needs of existing customers. The advantage of horizontal diversification is the versatile satisfaction of consumer needs. The disadvantage is the risk of a decrease in the sales market. This leads to a change in activity as a whole.

3. Conglomerate diversification - replenishment of the company's assortment with products unrelated to the technologies used, the markets in which the company operates, or the existing needs of consumers. This type of

diversification requires the highest financial costs and can be applied only by large, profitable enterprises.

In [33], the following types of diversification are defined:

- diversification with vertical dominance;

-diversification with limited vertical dominance, when diversification is focused on one of the vital positions in the market or on one resource;

- diversification associated with a vertical integration dominant, when diversification is focused on several strong positions or several resources at the same time;

- unrelated diversification;

- conglomerate diversification, creation of conglomerates by acquiring new enterprises;

- passive diversification.

Thus, the diversification of construction enterprises consists in expanding the enterprise's activities to develop new markets, reduce risk and increase profits. The choice of diversification strategy depends on the management of the enterprise. Deciding on the implementation of a specific strategy is an important step in ensuring the efficiency of a construction enterprise.

To implement diversification strategies at a construction enterprise, it is necessary to conduct an enterprise analysis, research existing strategies and propose new diversification strategies. The primary task for the formation of effective adaptive management of a construction enterprise in terms of diversification is the analysis of enterprises. The following research sequence is proposed (Fig. 1.2):

1. Evaluation of the external environment in which the enterprise operates.

2. Analysis of the enterprise from the middle: evaluation of the management of the enterprise, its organizational structure.

3. Market structure analysis. Estimating the profitability of sales markets for goods and services.

4. Evaluation of current corporate diversification strategies, if they exist.

5. Creation of new strategies. Calculation of financial effect and risks from implemented diversification strategies.

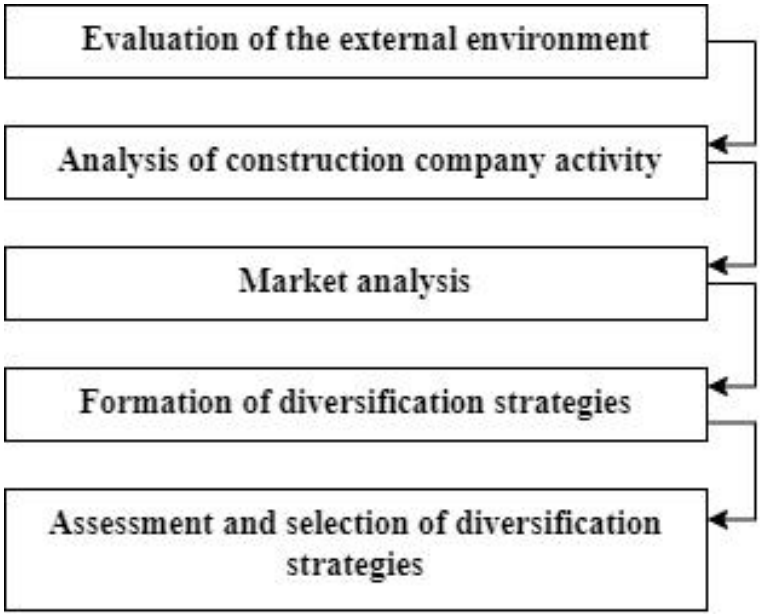

Figure 1.2 – Scheme of the study of the enterprise before the implementation of diversification strategies

The key factors affecting the activity of a construction enterprise are:

1. Factor of the external environment: presence of competitors, partnerships with other companies, entry into regional construction clusters.

2. The factor of strategic management of the enterprise.

3. Organizational structure of the enterprise.

4. Enterprise productivity.

Analysis of construction enterprises in Ukraine shows that about 40% of enterprises use related horizontal diversification strategies in their activities, 27% use unrelated strategies, 9% use vertical strategies, and 24% do not use any of them.

We will describe the classification of risks of a construction company:

1. Cost risk. This type of risk includes changes in requirements for construction during its execution, increases in prices for materials, peculiarities of construction planning, and changes in the time required to complete individual tasks.

2. Risk of time. This type includes time spent on work, reduction of time for individual work, and bureaucracy.

3. Risks related to quality: quality performance of work, qualification of employees, and quality of managerial work.

4. Risks associated with the environment: noise pollution, soil and air conditions in the area allocated for construction.

5. Risks related to safety: non-compliance with safety rules at the construction site, qualification of workers.

From this classification, seven main risks that arise when managing the activities of a construction enterprise were analyzed and identified:

- time consumption, reduction of time for individual work;
- rising prices for materials and workers' work;
- effectiveness of planning and management of the activities of construction enterprises;
- bureaucratic procedures;
- low competence of employees;
- the occurrence of changes in operational construction management;
- environmental risks.

1.2. Features of the application of multi-criteria decision-making methods for the management of construction companies

The choice of enterprise diversification strategies is a difficult task, as it is usually carried out based on a whole list of criteria with varying degrees of importance. However, their consideration is mandatory when making the final decision. This decision directly affects the enterprise's profit and determines its future risks. Therefore, the choice must be rational.

Multi-criteria decision-making methods can be used to choose a rational diversification strategy. In recent decades, such methods have been intensively developed due to their significant relevance; new methods appear, and already-

known ones are modified and improved. In this paragraph, the primary known methods of multi-criteria selection from a set of alternatives are considered, and their general assessment is made regarding the possibility of application in the case of choosing diversification strategies for construction enterprises.

The first group of methods presented in the review are based on the theory of fuzzy sets. The theory of fuzzy sets and fuzzy analysis is an effective tool for making multi-criteria decisions [35]. The theory of fuzzy sets is an extension of classical logic that allows solving weakly structured problems associated with insufficient information or processing of inaccurate data. A feature of applying methods using fuzzy logic for a multi-criteria selection problem, which can help solve the problem of choosing diversification strategies for construction enterprises, is the possibility of solving complex problems based on only a few fuzzy rules. The disadvantage of using fuzzy methods for this task is the need to conduct many experiments before the appropriate methods can be used to select fundamental diversification strategies.

We will give a brief overview of recent works related to applying fuzzy logic methods for the problem of multi-criteria selection. The work [36] examines methods of ranking alternatives and offers a heuristic approach to determining the importance of criteria based on fuzzy logic and similarity analysis. Work [37] considers the decision-making process, particularly for risk assessment, based on fuzzy procedures. In work [38], the problem of order management is considered based on fuzzy methods of ranking these orders, which allows the classification of them according to time. The work [39] considers the method of ranking alternatives based on the economic effect of their implementation.

A famous mathematical method for solving complex decision-making problems is analyzing hierarchies [35, 40]. The central assumption of this method is the use of pairwise comparisons to evaluate alternatives according to various criteria. The advantage of analyzing hierarchies is that it is simple to apply to a broad class of problems, it is easily scalable, and experts' preferences are easily determined. However, the peculiarity of the method is that it only provides an

opportunity to evaluate an object separately from others by identifying advantages through paired comparisons [41].

Stages of the method of analysis of hierarchies [42]:

1. Construction of a hierarchy that expresses the problem, considering alternatives, criteria, and goals.

2. The application of the method of paired comparisons is to establish the priorities of all hierarchy components.

3. Creation of general priorities for alternative options by constructing a convolution, as a rule, linear from the priorities of the components of the hierarchy.

4. Study the obtained results for adequacy and compliance with the set goal.

5. Making a decision based on the received general priorities, considering all possible pairwise comparisons.

The application of the method of analysis of hierarchies is pervasive. In particular, in [43], hierarchies were analyzed to study urban water supply systems. In work [44], an attempt was made to combine different approaches to multi-criteria analysis to identify risks in the assessment of transport infrastructure. This method was necessary because when applying only one of the methods of multi-criteria analysis, the correctness of the choice of weighting factors of the criteria significantly influences the correctness of the decision. This effect is reduced in the case of a combination of different methods. In [45], an attempt to build a hybrid multi-criteria decision-making model, which combines the principles of the analytical network (ANP) and the methodology of laboratory research (DEMATEL), is substantiated. The application of this hybrid model concerns the field of trade. In the last decade, scientists have combined it with other methods of multi-criteria decision-making for the practical implementation of the method of analysis of hierarchies.

Moreover, as a rule, this combination is expressed in the built combined models of the hybrid type or, less often, of the selective type. An analytical network is an extension of the method of analyzing hierarchies and allows for establishing preferences between clusters or groups of objects. Decision-making

methods based on analytical networks can be used for planning tasks, especially for management and selecting alternative projects according to a set of criteria.

The MAUT (Multi-Attribute Utility Theory) [46] theory is used to assess risks and the degree of uncertainty, as well as to make multi-criteria decisions [46] At one time, this theory was most often used for multi-criteria problems, in particular, in work [47] based on it, the method of determining risks of using land resources. In work [48], MAUT determines placement under production organization. In many studies, MAUT is primarily focused on natural resource management, but it can also be used for other risk assessment and multi-criteria decision-making tasks. In particular, the work [49] analyzed the approach to using MAUT for the problem of multi-criteria selection in order to avoid or reduce risk. The methods described in this paper made it possible to identify weaknesses in the risk assessment of the entire industry, which contributed to the correction of errors and a more adequate calculation of the assessment parameters. The work [50] describes the use of MAUT for the task of providing first aid in the case of evacuation measures and emergencies. The work [51] describes a model based on MAUT, which uses institutional, cultural, technical and other criteria designed to contribute to the stability and development of individual regions. Based on this model, the SANEX decision support system was created and successfully implemented in Indonesia. The use of MAUT for multi-criteria assessment of climate change trends is described in [41]. In [52], a combination of spatial analysis methods and multi-criteria analysis and decision-making methods based on MAUT was used to assess the risks of soil pollution in Europe.

The goal of multi-criteria decision-making based on MAUT is to calculate some function that determines the decision-maker's preferences according to n criteria at each stage of the method. The main advantage of MAUT is that it considers the uncertainty in the data. However, the disadvantage is the need to enter a large amount of data at each stage of the method that determines the preferences of the decision-maker, which can significantly complicate the implementation of the method as a whole. In addition, advantages should be

entered in the form of numerical coefficients, subjectively affecting the quality of the decision. Nevertheless, this method is used in agriculture, resource management, economic, financial and other problems with significant uncertainty.

Another method that can be used in multi-criteria selection is case-based reasoning (CBR). CBR consists in solving new problems based on previously solved ones. For example, if the task of making a multi-criteria decision for choosing a diversification strategy of a construction enterprise was considered earlier, then with a high probability that the scheme of constructing alternative strategies, the list of criteria and their evaluation may be identical, or at least very similar, which is appropriate to use for new tasks of evaluating diversification strategies.

The CBR method generally consists of the following four main stages [53]:

1. Selection from memory of cases directly related to the task and can help solve it. These cases should consist of a goal, a solution, an annotation, or a justification of how the solution was obtained.

2. Adaptation of the selected case to the given task, taking into account the goal, alternatives and criteria.

3. Modeling or checking whether the obtained solution can be applied to a new problem.

4. Saving the obtained solution in the case database if the adaptation was successful.

Let's consider some successful examples of implementing methods based on CBR. The work [54] describes a new forecasting method for financial instruments based on CBR. Information for verification was collected from trading results on the Shenzhen Stock Exchange in China. CBR with similarity calculation based on Euclidean distance and urban metric was used for prediction. The ROCBR (ranking-order case-based reasoning) method was developed in the work, which allows for finding similarities between fragments of information selected from the current task and information identified in the past. In [55], a modified CBR method for the problem of transport insurance is considered. Such a problem has a large

base of cases, so it is rational to solve it precisely based on the CBR method. The advantages of the method are that as the base of cases increases, the accuracy of the solution will improve. In addition, significant costs for the construction and maintenance of the database are not required. The response from such a database adapts over time, which is a natural response to changing environmental conditions. However, a significant drawback of the method is its sensitivity to data inconsistency, so a significant amount of previous cases, which are described in detail in the database, is a necessary condition for using the CBR method. Because of this, most of the applied studies using this method relate primarily to the field of insurance, evaluation of the result of drug treatment. Also, this method is widely used to compare enterprises, particularly their activity strategies, which can be useful when researching diversification strategies.

Another methodology that directly connects with multi-criteria optimization and system analysis is the analysis of the operating environment (Data Envelopment Analysis, DEA). This methodology allows for a thorough comparative assessment of the functioning of complex technical, social and economic systems and is based on linear programming [56, 57]. Using linear programming, DEA allows you to measure the relative efficiency of alternatives, which are then ranked in order of decreasing efficiency. The most effective alternative gets a score of 1, and all other alternatives compared to this one get a score of less than 1. Moreover, the closer the score is to 1, the more rational the alternative is for choosing. This information is provided to the decision-maker. Of course, assessment can be both quantitative and qualitative.

The disadvantage of the DEA method is that there must be accurate data or data with complete information for its application. That is, the application of this method in conditions of uncertainty is complicated. However, the method works well in cases where the effectiveness of alternatives must be compared. Therefore, applying this method can successfully solve the problems of agriculture, trade, medical industry, business, etc.

The paper [58] considers the problem of linear programming for calculating

efficiency for a decision-making unit based on DEA. The verification of this study was carried out to evaluate the efficiency of the activities of companies specializing in the production of liquid crystal displays in Taiwan. Also, the DEA methodology was successfully used for agricultural problems in India [59]. The authors were able to rank farmers from the most efficient to the least efficient to highlight weaknesses in the agricultural sector of a particular region. A similar concept can be successful in ranking the diversification strategies of construction companies, so it is valuable for dissertation research. The work [60] suggested using the DEA method to evaluate education's effectiveness in 30 universities. In general, the method proposed in this paper made it possible to rank the efficiency of the selected universities in order of decreasing efficiency. There are also successful results of using this method for multi-criteria selection of investment decisions, in particular for large industrial companies and holdings [35].

Let's consider a few more methods of multi-criteria decision-making that have proven effective. The paper [61] describes the SAW (simple additive weighting) method or the method of ordinary weighting. The method is based on adding the evaluations of goal achievement for each alternative criterion, considering the weights of these criteria. The advantage is a straightforward calculation that may not require technical means, so this method is often used in business, the financial sector for quick calculations when establishing a rational alternative.

The ELECTRE (ELimination and Choice Expressing REALITY) family of methods is also used to analyze multi-criteria decisions. The classic ELECTRE method consists of two main steps:

1. Establish the preference ratio between each pair of alternatives according to various criteria.

2. The procedure for forming recommendations and conclusions based on the results of the first stage. This stage depends on the objectives of the task, in particular, what the decision maker wants to see: ranking of alternatives, choice, etc.

The ELECTRE method may require the application of concordance analysis,

as the ratio of preferences obtained from different experts may vary. The advantage of the method is the possibility of its use in the presence of uncertainty; it can also be applied in combination with fuzzy methods that involve blurring data and qualitative evaluation of alternatives. These advantages are important for many economic, ecological, energy and other problems [35, 62].

Another method of multi-criteria analysis is the SMART method. The method is a simplified form of MAUT. The method is believed to be quite successful in converting importance weights into numerical ratings. The method is easy to use and does not require constant involvement of decision-makers at all stages of calculations. However, a necessary condition for its use is sufficient information about alternatives and the presence of an expert environment. The results of using the SMART method in construction, logistics, transport management, and production are described [41].

The PROMETHEE family of methods is similar in content to the methods of the ELECTRE class because they use the ratio of pairwise preferences between alternatives. The method is easy to use, but there are difficulties in assigning weights, which does not rule out its effective use in agriculture, business, chemical production, etc. [35]. In table 1.1. the considered methods of multi-criteria analysis, their main advantages and disadvantages are given [35], and the main areas of application of these methods are indicated the possibility of their application to evaluating diversification strategies for construction enterprises is analyzed.

Based on the results of the analysis of known methods of multi-criteria decision-making and multi-criteria analysis, it can be concluded that most methods consider uncertainty conditions to one degree or another. However, their use in isolation can complicate the interpretation of results. Since there is a problem in the research task, which in the case of an incorrect solution can lead to significant financial losses, it is proposed to use several methods that focus on decision-making in conditions of uncertainty, preferably taking into account fuzzy data, to select alternatives that reflect the diversification strategies of construction enterprises, are relatively simple to implement and allow intuitive interpretation of

the results (available scales of quantitative or qualitative assessments) without the constant involvement of experts or a decision-maker. Also, an important task of the constructed method should be a clear understanding of the advantages of some alternatives over others, which allows us to adjust the final decision if necessary.

Table 1.1. Review of multi-criteria decision-making methods

N	Methods of multi-criteria decision-making	Advantages	Disadvantages	Possibilities of application
1	Theory of fuzzy sets and fuzzy analysis	Takes into account the blurring of data, is used in conditions of uncertainty	It is difficult to implement and needs additional numerical studies before starting to use it	It can be used to choose diversification strategies, as it assumes the presence of vague criteria. It is also used in economics, management, social affairs, and medicine.
2	Hierarchy analysis method	Easy to use, allows you to solve small tasks in a short time	Contradictions in the ranking of alternatives due to existing dependencies between criteria and alternatives.	It can be used to choose diversification strategies, but it needs enough information to make a correct ranking, which is difficult in conditions of uncertainty. It is used in resource management and activity planning.
3	MAUT	It is used in conditions of uncertainty	A lot of information must be entered, the advantages of the alternatives in pairwise comparisons must be rigorous	It can be used to choose diversification strategies because it takes into account the uncertainty of the data. Also used in economics, finance, agriculture, etc.

Continuation of table 1.1.

N	Methods of multi-criteria decision-making	Advantages	Disadvantages	Possibilities of application
4	Method of case-based argumentation	Adapts to changes in the environment, improves with the increase of the base of described cases	Requires a sufficiently large case base. Also, the method is sensitive to incorrectly entered information.	For the selection problem, a diversification strategy can be applied if there is a sufficiently large amount of data. In conditions of uncertainty, the application of the method is complicated. Used in design, business, insurance, etc.
5	The method of analysis of the functioning environment	Ability to work with several inputs and outputs.	In case of data inaccuracy, the method does not work. All entrances and exits must be known in advance.	It is used in agriculture, medicine, economy, etc. It is difficult to apply this method to the task of choosing diversification strategies, due to the fact that the choice of strategies takes place under conditions of uncertainty and risk.
6	Method of usual addition of weights	The method is simple, does not require the use of appropriate software complexes.	The obtained results are often not explained from the point of view of logic, that is, sometimes the results do not correspond to the state of the real object of	It can be used only as an additional method of evaluating alternatives, in combination with other methods. In general, the method found its application in business problems and in financial mathematics.

			research.	

Continuation of table 1.1.

N	Methods of multi-criteria decision-making	Advantages	Disadvantages	Possibilities of application
7	SMART	The method is simple, does not require the efforts of decision-makers.	The calculation procedure is not convenient.	It is used in construction, transport, logistics, and production. For the task of choosing alternatives that reflect the diversification strategies of companies, it can be used in combination with other methods of making multi-criteria decisions.
8	ELECTRE	The method takes into account uncertainty conditions.	It is difficult to interpret the results of calculations without the involvement of experts. Advantages and disadvantages of alternatives are not identified.	Taking into account the conditions of uncertainty, the application of the method is appropriate, but the method has significant drawbacks. It is used in energy, ecology and transport networks.
9	PROMETHEE	The method is easy to use.	Difficulties with determining the weighting coefficients of alternatives.	It is used in finance, agriculture, hydrology, water resources management, etc. For the research task, it can be applied in combination with other methods.

Therefore, in general, the constructed new or combined method, considering the results of other methods, should be focused not only on choosing one alternative from a set of admissible alternatives, but form a ranked list of them. This list is provided for consideration by the expert environment and the person who decides to determine a rational strategy for diversifying the company's activities.

In addition, a separate difficult task is not only the evaluation of diversification strategy alternatives but also the formation of these strategies. The difficulty is mainly manifested in conditions of uncertainty when there is not enough information about the possible consequences of implementing a particular strategy. The complexity of forming diversification strategies for construction enterprises is related to several factors:

1. The construction industry can be very diverse, and forming diversification strategies requires careful analysis of different market segments and their potential advantages and limitations. That is, this factor is determined by the specifics of the industry, which is complex and heterogeneous.

2. Many stakeholders may be involved in the construction industry, including customers, contractors, material suppliers, regulatory bodies, etc. It is necessary to consider all these stakeholders' interests when forming diversification strategies. This factor is related to the difficulty of simultaneously considering the needs of many stakeholders.

3. Diversification strategies may require significant financial resources, which may be a limitation for some construction companies. This factor determines financial constraints. The construction industry operates in conditions of significant financial costs, and choosing the wrong strategy can lead to significant, sometimes irreparable, losses. Therefore, the choice of alternatives should be approached as carefully as possible.

Diversification can be difficult because the need to manage the risks associated with different industries or projects. The construction industry can function simultaneously in a complex of several other industries. In particular, the

construction of plants or factories must consider environmental restrictions and possible changes to these restrictions, the development of the urban environment, changes in production needs, etc. Residential construction should consider population growth in the construction area, etc.

As a backbone industry in most countries, the construction industry is a primary driver of national economic development. It plays a significant role in the promotion and development of urbanization and increasing the level of employment [63, 64]. The construction industry provides almost 7% of jobs worldwide [65]. According to the National Bureau of Statistics of the People's Republic of China [66], the construction industry provides about 30 million jobs and accounts for 7% of GDP. However, the construction industry consumes many construction materials and emits much carbon dioxide during production activities [67]. The construction industry is characterized by the second largest carbon emission in the world, accounting for approximately 33% of global carbon emissions [68]. In China, the construction industry consumes a significant amount of energy, accounting for almost 30% of China's total annual national energy supply [69]. The construction industry leads to many problems, such as disturbance of biodiversity, generation of greenhouse gases and carbon emissions, generation of waste [70, 71] and health and safety incidents [72], accounting for 30–40% of casualties all over the world [65]. Due to the rapid growth of the construction industry in China in recent years, its impact on society and the environment is increasing, and the importance of corporate social responsibility is also increasing. Work [73] shows that the Chinese construction industry has low awareness of corporate social responsibility practices. These practices include corporate governance, environmental management, occupational health and development, economic responsibility, and community development. Public enterprises are more concerned with social responsibility, while private enterprises focus more on increasing profits. Therefore, another component that should be paid attention to is the peculiarities of forming the general concept of the development of construction companies, which is determined by the institutional environment.

Also, in choosing diversification strategies, it is necessary to pay attention to technological diversification. Technological diversification means that the construction enterprise's technological activities and stock of technological knowledge cover several technological fields. This is necessary to strengthen or develop new technological capabilities [74, 75]. The key interest here is related to technological diversification. This means that although the technologies of enterprises are distributed in different fields, the difference between the elements involved in the technological knowledge base is relatively small, and the degree of connection between technologies is relatively high. Enterprises invest in developing research equipment, human resources and capital in similar scientific and technological fields, contributing to achieving a higher learning effect and a cumulative effect for the company's development [74].

The relationship between technological and production diversification is an important issue that is considered in works [76-80]. The connection between the implementation of technological diversification and technical competencies is considered in works [81-83]. Works [84-90] provide thorough reviews of research and knowledge in the field of diversification of companies. However, the creation of information technologies, methods and models that would allow forming, evaluating and choosing rational diversification strategies of construction companies, taking into account the requirements of the participants in the construction process and taking into account the peculiarities of the technical and economic parameters of construction, have not yet been sufficiently developed [91-95].

Despite the difficulties that arise and accompany the formation and evaluation of diversification strategies of construction enterprises, this task is relevant. The relevance of the task of diversification for construction enterprises is based on several key factors:

1. Demand for the development of the construction industry in conditions of rapid economic growth in countries with favorable conditions. Rapid economic growth is manifested in an increase in the country's GDP, an improvement in the

population's standard of living, an increase in employment, the development of infrastructure, an increase in the volume of trade and foreign investment, etc. The People's Republic of China is known for its impressive economic growth over the past decades. This achievement was possible due to rapid industrialization, an export-oriented approach to the economy, and the comprehensive implementation of reforms.

2. Demand for the development of the construction industry in the conditions of post-war reconstruction. After the end of martial law in Ukraine, the question of rapid restoration of the infrastructure, housing stock, town-building industry, manufacturing, etc. arises. This process can be essential for restoring the affected regions' economic stability and social well-being. Restoring roads, bridges, railways, airports and other infrastructure elements is necessary to restore economic life in the affected regions. This helps facilitate the movement of people and goods and creates conditions for developing enterprises and other spheres of activity. Reconstruction of the housing stock is one of the most important aspects after a war or a natural disaster. This may include the reconstruction of destroyed houses, the construction of new housing for the victims and the creation of conditions for their return to the destroyed areas.

3. Reduction of risks. The construction industry is known for its high vulnerability to economic fluctuations and changes in the market situation. Diversification allows you to reduce the risks associated with specific projects or markets.

4. Diversification can help businesses use their resources, such as human resources, equipment, and technology, more efficiently by expanding their applications in different markets or industries.

5. Diversification can give a construction company a competitive advantage, providing it with a more flexible and adaptive business approach, which will expand the range of services to meet the needs of different customers.

Conclusions to chapter 1

1. The chapter describes the features of diversification of construction enterprises, basic concepts, types of diversification and the possible effect of diversification of activities. The system of indicators that determine the enterprise's ability to implement diversification is also described in the work. Such indicators include the specialization ratio (SR), the related ratio (RR), the ratio of adjacent essential resources (CR), and the vertical ratio (VR).
2. The relevance of the development of the construction industry and the diversification of the activities of construction companies are substantiated. The construction industry provides almost 7% of jobs worldwide. According to the National Bureau of Statistics of the People's Republic of China, the construction industry provides about 30 million jobs, accounting for 7% of GDP. However, the construction industry consumes many construction materials and emits much carbon dioxide during production. In China, the construction industry consumes a significant amount of energy, accounting for nearly 30% of China's total annual national energy supply. Therefore, the formation and evaluation of diversification strategies of construction enterprises, in particular technological diversification, is an urgent task today.
3. The possible consequences after the diversification of the construction industry are characterized, in particular, in conditions of uncertainty and risk: more effective use of human resources, equipment and technologies, reduction of risks, and intensification of post-war reconstruction (especially in Ukraine), an increase in the level of development of infrastructure, manufacturing and residential construction in the industry countries with rapid economic growth (in particular, China).

4. The well-known methods of multi-criteria decision-making are described, which motivate the application of decision-making strategies regarding the diversification of the activities of a construction enterprise in the conditions of formation and evaluation. It is indicated that since diversification strategies can have a significant number of evaluation criteria due to the presence of many stakeholders, financial needs, diversity and heterogeneity of the industry, the application of new or modification of known methods of multi-criteria decision-making can help solve the task of evaluating diversification strategies.
5. It was established that due to the heterogeneity and diversity of the construction industry, as well as due to uncertainty, the task of forming and evaluating diversification strategies is difficult. Therefore, it should be a partial task of managing a construction company's organizational environment. This is the only way to ensure the growth of the company's profitability and the promotion of global changes beneficial to stakeholders and the state, which will impact the development of the construction industry as a whole. The application of the task of evaluating diversification strategies locally will not significantly change the efficiency of the construction company and can be used for small enterprises. Since assessing the diversification strategies of construction companies is complex and has many influencing factors, it is essential to develop information technology that would significantly simplify the work of the construction company's decision-maker or management team.

CHAPTER 2. THE CONCEPT OF FORMING DIVERSIFICATION STRATEGIES OF CONSTRUCTION COMPANIES AS PART OF THEIR ORGANIZATIONAL ENVIRONMENT

2.1. Creation of the organizational environment of the construction company, taking into account the diversification of its activities

Let us consider the peculiarities of the work of a construction company and the decisions related to diversification activities that may arise in conditions of uncertainty. The activity of any construction company includes a set of actions to ensure and manage the process of creating buildings from the project to the completion of construction and commissioning. This activity is included in the task environment and can be divided into the following directions:

- registration of documents regarding the rights to the land plot on which construction is planned. This task is complex and falls within the legal sphere;
- finding investors who can finance the construction or the formation of a financial package that describes all construction costs;
- preparation of documents related to the actual construction, in particular the construction project;
- construction of the building, involvement of necessary specialists;
- putting the building into operation and managing the construction site in the future, in particular, leasing the building, selling it, etc., depending on the purpose of the building.

The described components can be adjusted depending on the purpose of the building (residential building, non-residential building). It should also be noted that in crisis conditions, particularly martial law and economic instability, the work of a construction company and the implementation of the specified tasks are associated with risk and uncertainty. In addition, if we do not consider the difficult economic circumstances and the state of war in Ukraine, then in any country, to one degree

or another, the construction process is associated with risk. In particular, in the People's Republic of China, due to economic growth, intensification of economic ties, and changes in the competitive environment, risk and uncertainty are increasing, especially when managing young construction companies that have not yet proven themselves in the market. The amount of risk can be reduced if you respond promptly and effectively to events that occur during the construction process. However, it is almost impossible to reduce the risk in the presence of uncertainty. That is why an important component of the construction company's activity is collecting information from various sources, including external verified sources, to reduce the probability of unforeseen situations during construction, document preparation, putting the building into operation, etc.

Let some construction company B be given, the main activity of which is the creation of real estate objects and the organization of relevant processes during construction. The organizational structure, activity specifics and the history of this company's creation of projects and construction objects are known. We will also assume that the company's activities occur in uncertain and risky conditions. Suppose that a study of the activities of company B revealed that it is necessary to implement diversification measures to increase profits and reduce risks. The goal is to form diversification strategies, evaluate them, and organize the company's work in such a way as to simplify the identification of possible risks for the effective management of the company in uncertain conditions.

The evaluation and implementation of appropriate diversification strategies will simplify the identification of risks for the timely adjustment of the construction company's activities in uncertain conditions.

The choice of the best or rational solution is a traditional approach to the rationalization of alternative selection schemes in the activities of a construction company. A triple is often considered for this

$$\{S, O, R\}, \tag{2.1}$$

where S – set of alternatives, P – principles of optimality or rationality, R – conditions of selection and results of alternative selection. It is clear that to find a

solution to the problem of choosing or ranking alternatives, it is necessary to apply the multicriteria analysis apparatus, and it is necessary to take into account, first of all, the methods of multicriteria decision-making used in conditions of uncertainty.

In this case, there are three main stages in the decision-making process:

1. Detailed identification and description of alternatives (in the case of the study - diversification strategies) and criteria for selecting rational alternatives.

2. Carrying out numerical calculations based on the selected multicriteria analysis method, taking into account the criteria weights to determine the appropriate assessments of alternatives.

3. Processing the obtained estimates to select a rational alternative or ranking of alternatives in order of preference for implementation by the described criteria.

These measures are necessary to overcome or reduce risks. It should be noted that the risks that accompany the activities of a construction company have their characteristics. In general, there are five classes of risks in this case, which are mostly related to change management:

1. Risk of possible expenses. This class of risks in the activities of construction companies includes:

- rising prices for construction materials during the construction process, which was not included in the project estimate;
- the need to change the construction schedule, for example, reducing the time for completion and the need to deliver the building earlier than the projected date;
- changes in the requirements for the building during construction, in particular, due to lack of coordination with stakeholders or investors;
- changes in the bureaucratic processes of obtaining construction permits, commissioning, etc., which directly leads to changes in the duration of construction and disruption of work schedules;

- imperfect work planning at the beginning of construction and during the process, especially for new construction companies with little experience.

2. The risk of incorrect assessment of work. This class of risks includes poor quality assessment or incorrect assessment of the work of contractors involved in construction, such as subcontractors, poor quality of management work, problems with planning and organization programs at the construction site, poor coordination between construction participants, etc.

3. Time risk. This class of risks includes delays in bureaucratic procedures, time spent on high-quality work, changes in the duration of certain work, etc.

4. Environmental risks and risks related to the environment, including the impact of construction on the environment in the region, in particular if the construction is manufactured, noise pollution, possible impacts on the cost of construction due to lack of information on the presence of groundwater in the soil under the construction site, etc.

5. Safety risks include poor quality of construction workers and non-compliance with safety rules, insufficient qualifications of the workforce, etc.

All risk classes are not separate from each other and are closely interrelated. Where the risk from one class increases, the risk from another class may increase. Therefore, we can identify critical risks that can affect the quality and performance of construction. These include:

1. Financial risk (insufficient financial resources to complete projects, rising materials costs, labor and equipment).

2. Technical risks (technical problems during construction, such as defects in the design or materials and unexpected technical problems that arise during the operation of the finished facilities).

3. Planning and scheduling risks (delays in project implementation, changes in customer requirements or construction project conditions).

4. Legal and regulatory risks (legal claims from customers or third parties, bureaucratic difficulties in putting the building into operation or at the planning stage of construction)

5. Safety risks (injuries and accidents at construction sites).

6. Changes in market conditions (changes in demand for real estate or construction services, prices for services and construction materials, and the finished real estate).

It has been researched that overcoming risks in the work of a construction company is a complex task, which is associated with the complexity of each risk and the connection of different types of risks. Changes in market conditions, such as a decrease in demand for real estate, immediately affect financial risks, as investors may underfund a construction project due to the loss of possible financial gains, etc. One of the ways to identify risks and reduce their impact on a construction company is to create and implement diversification strategies. Let us consider the place of diversification activities in the company's organizational environment. To do this, we need to define the concept of the organizational environment of a construction company.

The organizational environment of a construction company is a set of all factors and conditions that affect its operations and development. The organizational environment may include economic, social, political, legal, technological and natural factors that affect the company's operations. The organizational environment affects all aspects of a construction company's activities, from strategic planning to production processes and the organization of stakeholder relations. There must be a shared understanding of what is included in the organizational environment. However, in the classical sense, the organizational environment of a company includes the internal environment, the task environment and the general environment. The internal environment includes interactions with the company's owners and employees and generally includes the company's organizational culture. The task environment includes cooperation with customers and partners, interactions and analysis of competitors, etc. The general or external

environment includes technological, international, political, economic, and social factors influencing the company's activities.

\ Diversification activities are separate in this concept of the organizational environment (Figure 2.1). However, diversification activity is one of the key elements of the environment that directly affects the development of the enterprise and is influenced by elements of other environments. Therefore, it is necessary to adjust the concept of the organizational environment (Fig. 2.1) and build an improved structural model of the organizational environment for construction companies, which will combine the entire range of activities of companies in conditions of uncertainty.

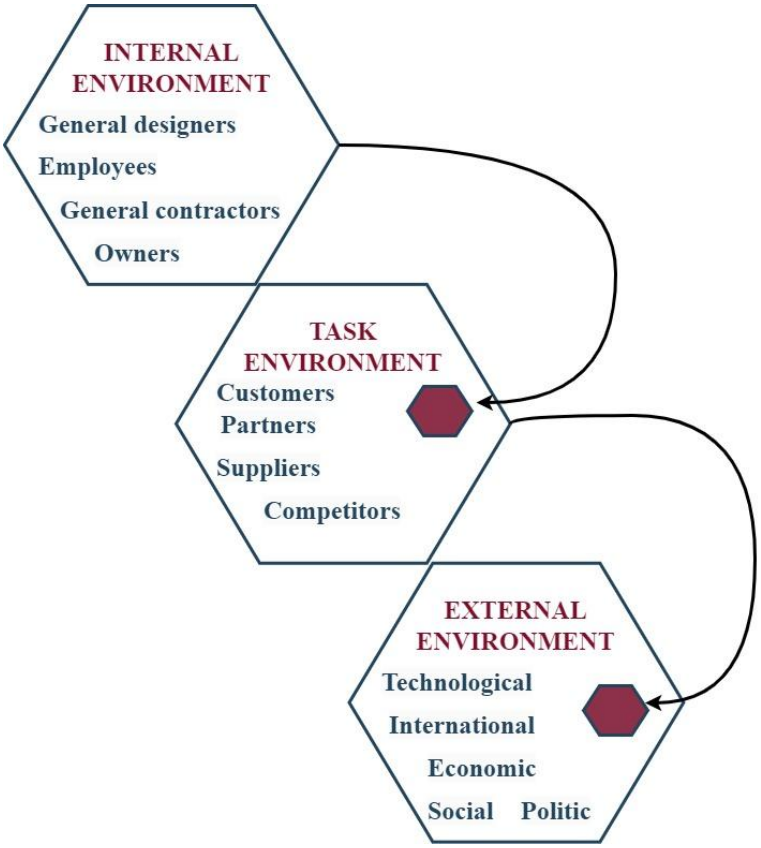

Figure 2.1 - General scheme of the organizational environment of construction companies, considering diversification activities.

Therefore, since diversification is an activity, the place of this element in the structure should be in the task environment. Moreover, diversification activities as

an element of the task environment will interact with other elements of this environment. The peculiarity of diversification activities is that they are related to the internal environment, since organizational culture, priorities and motivations of the company's owners and the qualifications of employees are factors that influence the implementation of the diversification strategy. In turn, the success or failure of the diversification strategy directly affects the owners, employees and may affect the current organizational culture of the company.

On the other hand, implementing a company's diversification strategies depends on the external or general environment and especially on technological and economic factors. Technological factors influence the implementation of technological diversification, without which it isn't easy to imagine a developed company. Therefore, technological diversification is exciting in this process. Technological diversification is a strategic approach companies use to expand their capabilities and reduce risks by applying various technologies, including information technologies, in their product or service portfolio. The main goal of technological diversification is to reduce risk and ensure the company's sustainability in a changing environment. It allows to expand the range of products or services offered while increasing competitiveness, adapting to changes in market demand and entering new markets. For example, a construction company that specializes in traditional construction may consider implementing energy-efficient technologies, using modern building materials, introducing automated construction process management systems, etc. This will allow it to expand its range of services, attract new customers and reduce dependence on specific market segments.

Technological diversification may also include investing in research and developing new technologies that may become a competitive advantage for the company. Such innovations may be key to its future success and ensure market leadership. Technological diversification helps companies increase the efficiency of their operations and adapt to the rapidly changing and competitive business environment, which is especially true in the construction industry.

The external environment is directly affected by conditions of uncertainty, which is manifested by a lack of information about the impacts and possible turbulent influences, which complicates the analysis and planning of the company's diversification activities in general. Uncertainty is when information about the external environment or the results of one's actions is limited, unclear, or unpredictable. This means that the company cannot predict or control events that may affect its operations. In each element of the external organizational environment of a construction company, an element of uncertainty can be identified:

1. Economic uncertainty, including market changes, fluctuations in raw material prices, financial crises, etc., can create uncertainty for construction companies as these factors are difficult to predict.

2. Political uncertainty includes changes in the legal environment, including legislation and regulation, which may create business uncertainty. Political crises, wars, and political reforms can also lead to instability.

3. Technological uncertainty. Rapid technological change and innovation can create uncertainty for companies, as they may be unable to adapt to new technologies or strategies.

4. Social uncertainty. Changes in social trends, consumer preferences, and demographic changes can create uncertainty for businesses, as companies may need help adapting to these changes.

Figure 2.2 shows a structural model of the organizational environment of construction companies, taking into account diversification activities.

In general, such a conceptual understanding of diversification activities as part of the organizational environment is only the first, but important stage of changes in the principles of organizational management. Before applying the concept of forming, evaluating and implementing diversification strategies of a construction company, it is necessary to form a high-quality organizational environment. The described approach will make it possible to manage a construction company more flexibly, modernize and implement technological

diversification solutions where necessary, identify management decisions and respond effectively. For this purpose, engineering principles of company management can be applied. At the same time, the proposed structural model of the construction companies' organizational environment should be considered.

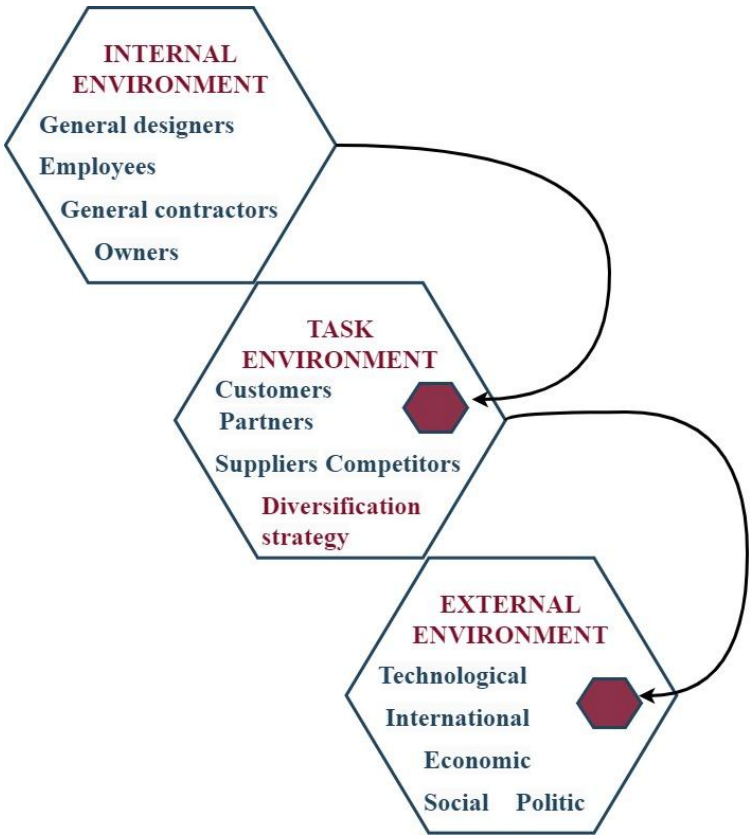

Figure 2.2 - A structural diagram of the organizational environment of construction companies, considering diversification activities.

The engineering methodology for managing construction companies should function at all company operations stages. At the same time, specific engineering approaches should be applied at each stage. It should be noted that each stage will have its own approach. For example, when forming the organizational structure of a construction company, organizational engineering is used. Organizational engineering ensures an effective process of reviewing, optimizing and improving the organizational structure, business processes, management and communication

systems to increase the company's efficiency and competitiveness. In addition to reviewing changes to the organizational structure, organizational engineering also allows you to optimize business processes, adjust approaches to human resources management, identify the best areas for implementing information technology, and improve quality and risk management efficiency. The peculiarity of organizational engineering is that this process should be continuous or dynamic.

Quality management includes implementing systems such as ISO 9001 and developing and implementing strategies to ensure high-quality products and services. Risk management allows for identifying and analyzing the risks associated with construction projects in conjunction with the peculiarities of the operating organization structure. The introduction of information technology into the activities of a construction company includes

- the automation and integration of construction processes;
- the use of project and resource management software;
- the provision of access to information and analytical tools for decision-making.

Human resources management includes optimizing the employment structure, developing training and professional development programs, and creating effective systems for motivating and retaining staff. Analyzing and reviewing key processes in the company, such as project management, procurement, production, and quality control, helps to reduce unnecessary costs, increase productivity, and improve the quality of tasks performed by the law firm.

A review of the organizational structure may include a review of the division of responsibilities and authority, management levels, chain of command, and hierarchical relationships. The goal is to create a more flexible and efficient structure that meets the construction company's needs. Figure 2.3 shows a general construction company management structure that can be implemented in a real company.

In addition to organizational due diligence, production, tender, financial, information and other types of due diligence are used to form the structure of a

construction company. In particular, production engineering involves organizing a construction site, supplying resources, equipment and controlling construction work. Financial engineering involves the formation of a construction budget, financing certain tasks of a construction project. Information engineering is another type of engineering that will allow you to qualitatively organize the process of managing a construction company. Information engineering involves developing and implementing information systems for managing construction work and projects in general. Also, risk management engineering is used to reduce risks and manage specific risks that manifest themselves in the activities of construction companies. In general, integrating engineering elements into the process of forming the company's organizational structure is the key to practical work and achieving the objectives of the company's projects on time and with high quality.

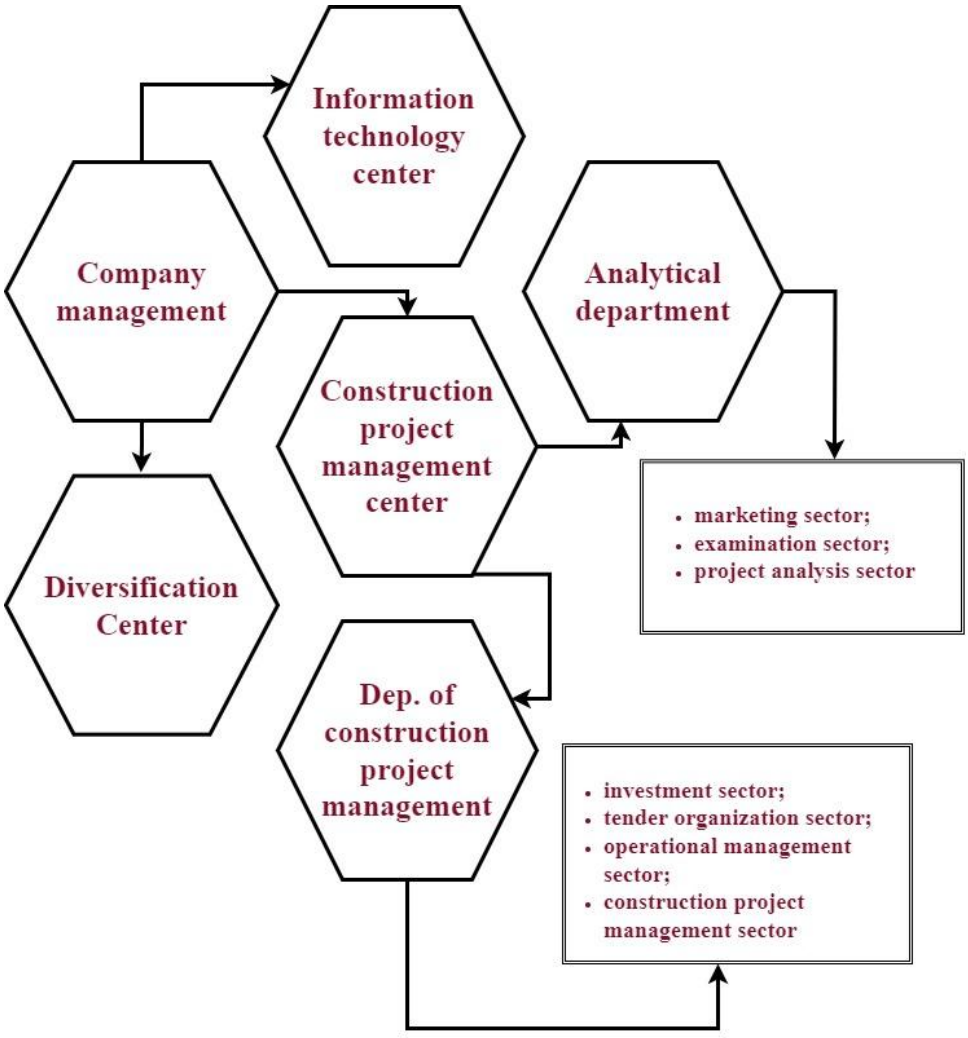

Figure 2.3. - General structure of the construction company management

Let us consider the general organizational structures that can be formed in the activities of construction companies. As we have defined, a construction company's organizational structure is the core at the center of the company's activities, i.e., it defines the internal environment. It connects it with the task environment and the external organizational environment. The task is to identify which of the known organizational structures are suitable for forming the internal organizational environment of a construction company, taking into account its intensive diversification activities. These structures are:

1. A structure that provides for the separation of the organizational structure and the project management center.

2. A structure in which the project management center is located in the body of the parent organization.

3. A structure in which the project management center functions as part of the parent organization. That is, the organizational structure accommodates the project management center and functions.

4. A composite structure in which two or more companies operate. There are three types of such organizational structures. The first is that a general contractor manages the construction project, and the client controls individual stages. In this structure, the general contractor forms the organizational structure, develops resource plans, and performs full project management. The second structure assigns a leading role in project management to the client, who allocates organizational resources, engages contractors, if necessary, etc. The third organizational structure assigns project management functions to a separate management firm specializing only in management. The firm provides certain functions to the general contractor and orders the services of contractors but does not perform any work on the project.

5. A structure in which two companies with different interests operate. It is necessary to organize the structure in such a way that the interests of both

companies are satisfied. To satisfy these interests, a separate board should be created to deal with issues of interaction.

In order to form an updated organizational structure of a construction company that would consider diversification activities, the effectiveness of various organizational structures based on engineering principles was analyzed and studied. Such a basic structure is a component of the internal organizational environment of a construction company. It will allow for the effective implementation of diversification measures, which is the key to increasing financial achievements. Figure 2.4 shows the main management areas in a construction company's organizational structure, taking into account the task environment. It includes pre-project work, creation of project documentation, project management, quality control and technological control, project financial management, and production and technological work, including procurement, logistics, and the formation of construction and operation contracts. All of this relates to the task environment, which is part of the organizational environment of a construction company. It should be noted that this structure includes a block of diversification activities, which includes planning, formulating and evaluating diversification strategies, implementing diversification strategies, and evaluating results.

After the essential part is built and substantiated, the optimal organizational structure is determined, and the organizational environment of the construction company is built. The development of diversification models can then begin. Different diversification models can be defined depending on the type of construction being considered. Models related to residential construction will have certain features. The first step is to build the technical and economic parameters of residential construction and determine the construction technology.

Construction technology is constantly evolving, using new materials, methods and innovations. The main trends in the choice of construction technologies include using environmentally friendly materials. There is a growing demand for materials that are less harmful to the environment. For example, wood, bamboo, glass, metal and other renewable or environmentally friendly materials

are becoming more popular. Another exciting trend is 3D printing of building materials. Other technologies include: modular construction (this approach uses prefabricated modules that are assembled on site), the use of smart materials (thermochromic polymers or self-healing materials that allow buildings to adapt to changing environmental conditions and reduce the need for repairs), the use of the Internet of Things (connected devices are installed in buildings to collect data on energy consumption, safety, comfort and other parameters, which allows for more efficient building management), green construction.

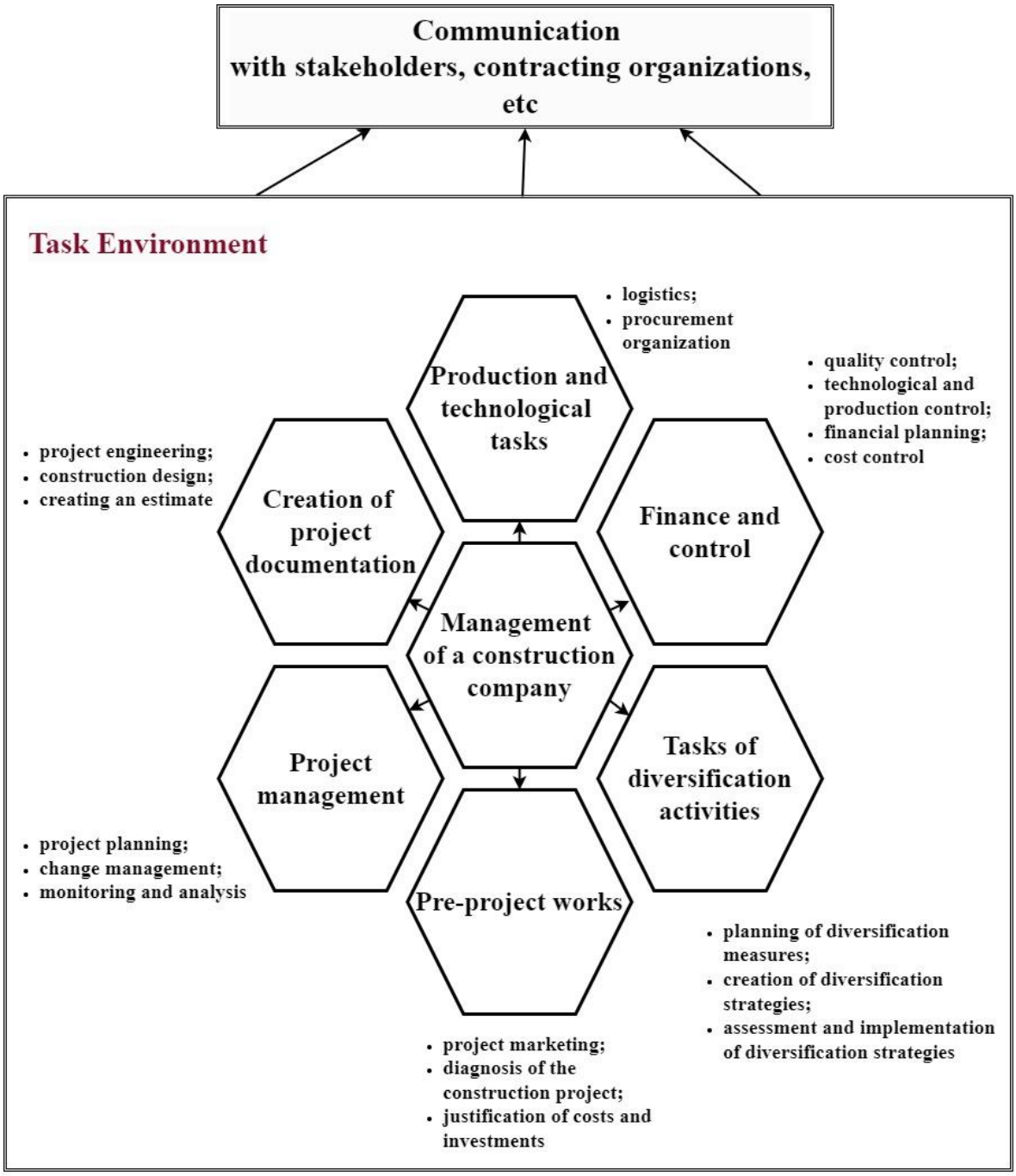

Figure 2.4. - General management structure of a construction company (task environment)

We will understand technology not only as a way of executing and implementing construction projects, but also as a set of actions and tools used to process materials, change their characteristics, place them in space, etc. This is necessary to create a complete building and construction project on time and with

high quality. We will assume that construction technology includes a set of such components:

$$T_B = \{C, M, P, Z, T, S\}, \tag{2.2}$$

where C – constructions, M – the material from which these structures are made, P – technological process of material processing, Z – performers, T – time costs, S – taking into account the impact of environmental conditions.

Each of the components is made up of a list of parameters that define this component of the construction technology. For example, residential building structures consist of the following elements: grillage, foundation, external envelope structures, utility networks, internal structures, etc. In other words, you can specify such parameters in this form:

$$C = \{C_1, C_2, \ldots, C_I\}, \tag{2.3}$$

$$\underline{C} \le C_i \le \overline{C},\ i = \overline{1,I}, \tag{2.4}$$

Each of the parameters has particular limitations. The limitations are related to the specifics of applying a particular technology.

Similarly, it is possible to determine the list and quantity of materials that have limits that meet regulatory requirements and are determined by the need to use certain materials in a particular construction technology, the availability of specific materials on the market, etc. That is, such a system of material parameters is defined as follows:

$$M = \{M_1, M_2, \ldots, M_J\}, \tag{2.5}$$

$$\underline{M} \le M_j \le \overline{M},\ j = \overline{1,J}. \tag{2.6}$$

You can also define a list of work parameters and the sequence of their implementation, as well as the performers. At each stage of construction, the limitations of technical means and the number of workers should be taken into account. Time constraints and the impact of environmental conditions are also considered. Each impact, like other parameters, is numerical and has upper and

lower limits, which are determined by the specifics of the construction technology, resource constraints, time constraints, etc. That is:

$$P = \{P_1, P_2, \ldots, P_K\},\ \underline{P} \le P_k \le \overline{P},\ k = \overline{1,K}, \tag{2.7}$$

$$Z = \{Z_1, Z_2, \ldots, Z_N\},\ \underline{Z} \le Z_n \le \overline{Z},\ n = \overline{1,N}, \tag{2.8}$$

$$T = \{T_1, T_2, \ldots, T_M\},\ \underline{T} \le T_m \le \overline{T},\ m = \overline{1,M}, \tag{2.9}$$

$$S = \{S_1, S_2, \ldots, S_Y\},\ \underline{S} \le S_y \le \overline{S},\ y = \overline{1,Y}. \tag{2.10}$$

Let's introduce the F function, which determines the success of a construction project. In this context, success in the implementation of a construction project is a comprehensive assessment that includes the effectiveness and quality of the project, its accuracy, timeliness, etc. The arguments of the F function are the selection function or selector C^R, which determines which of the parameters for each component of the technology is selected for implementation in a particular construction project, i.e. if

$$E = \{K, M, P, Z, T, S\}, \tag{2.11}$$

then

$$C^X : 2^X \to 2^X, \tag{2.12}$$

where 2^X - set boolean X, $X \in E$.

If construction company B completes d construction projects in a reporting period, for example, a year. Then you can formulate an objective function that will determine the success of the dth construction project:

$$F_d\left(C_d^K(K), C_d^M(M), C_d^P(P), C_d^Z(Z), C_d^T(T), C_d^S(S)\right) \to \max, \tag{2.13}$$

Then the potential of the construction company when choosing the appropriate components of the construction technology E is determined by the formula:

$$R_d^E = \left(C_d^K(K), C_d^M(M), C_d^P(P), C_d^Z(Z), C_d^T(T), C_d^S(S)\right),$$

$$(2.14)\ \Phi^E = F_d\left(R_d^E\right) \to \max. \tag{2.15}$$

The selection function determines which of the parameters should be selected for implementing a construction project, considering certain constraints. This choice should correspond to the features of the construction technology and meet the interests of stakeholders, investors, general contractors, owners, general designers, and other participants in the construction process. Each of the parameters usually relates to specific participants in the process. Therefore, it is essential to divide the parameters into areas of responsibility of specific stakeholders. These participants in the construction process, as individuals or legal entities, are responsible for the preparation and organization of construction works and the implementation of the construction process from start to finish. Thus, the task arises of considering not only the requirements of the construction technology but also the stakeholders' requirements. The scheme of interaction between the participants of the construction process, considering the high potential of the construction company, is shown in Fig. 2.5. It indicates that the internal environment of a construction company includes separately the owner, investor, general designer, developer, and general contractor, which are the basis. Each performs their role to implement the construction project and achieve its success and ensure the high productivity of the construction company.

Let's consider the external organizational environment of a construction company, the components of which are the main source of uncertainty that accompanies the activities of construction companies. The external environment consists of technological, international, political, economic, and social components.

The technological component of the external organizational environment of a construction company includes various technologies that affect the way the company functions and develops. Here are some key aspects of the technological component of the external environment of a construction company:

1. Construction technologies. The development of new building materials, construction methods and management systems can affect the efficiency of construction, product quality and competitiveness of the company.

2. Information technology. Using specialized software products to design, plan and manage construction projects can significantly increase the company's efficiency and reduce costs.

3. Digital technologies. The introduction of digital tools, such as Building Information Modeling (BIM), can improve coordination between participants in the construction process, reduce errors and optimize costs.

4. Energy-efficient technologies. The growing focus on energy efficiency and sustainable construction stimulates using the latest technologies to reduce emissions and energy consumption in construction activities.

5. Robotization and automation. Using robots and automated systems in the construction industry can increase productivity, reduce risks to workers, and improve the quality of work.

6. Innovative materials and processes. Developing new construction materials and methods can open up new opportunities to improve the quality and efficiency of construction.

7. Internet of Things (IoT): The introduction of IoT in the construction sector allows for the collection and analysis of data on the operation of buildings, optimizing their operation and maintenance.

Uncertainty in the technological component of a construction company's external organizational environment can manifest itself in several ways. Technology in the construction industry is constantly evolving, and new innovations can appear quite quickly. This can create uncertainty for companies as they have to quickly adapt to new technologies and change their processes and strategies. The introduction of new technologies can have unintended consequences. For example, a new construction management system may increase productivity but at the same time create data security issues or require additional staff training. Uncertainty also manifests itself in the activities of competitors. Competition in technology can be fierce. New technological solutions may provide advantages to competitors, or vice versa, a company may be ahead of the

competition through innovation. This creates uncertainty about which technologies will be successful in the future.

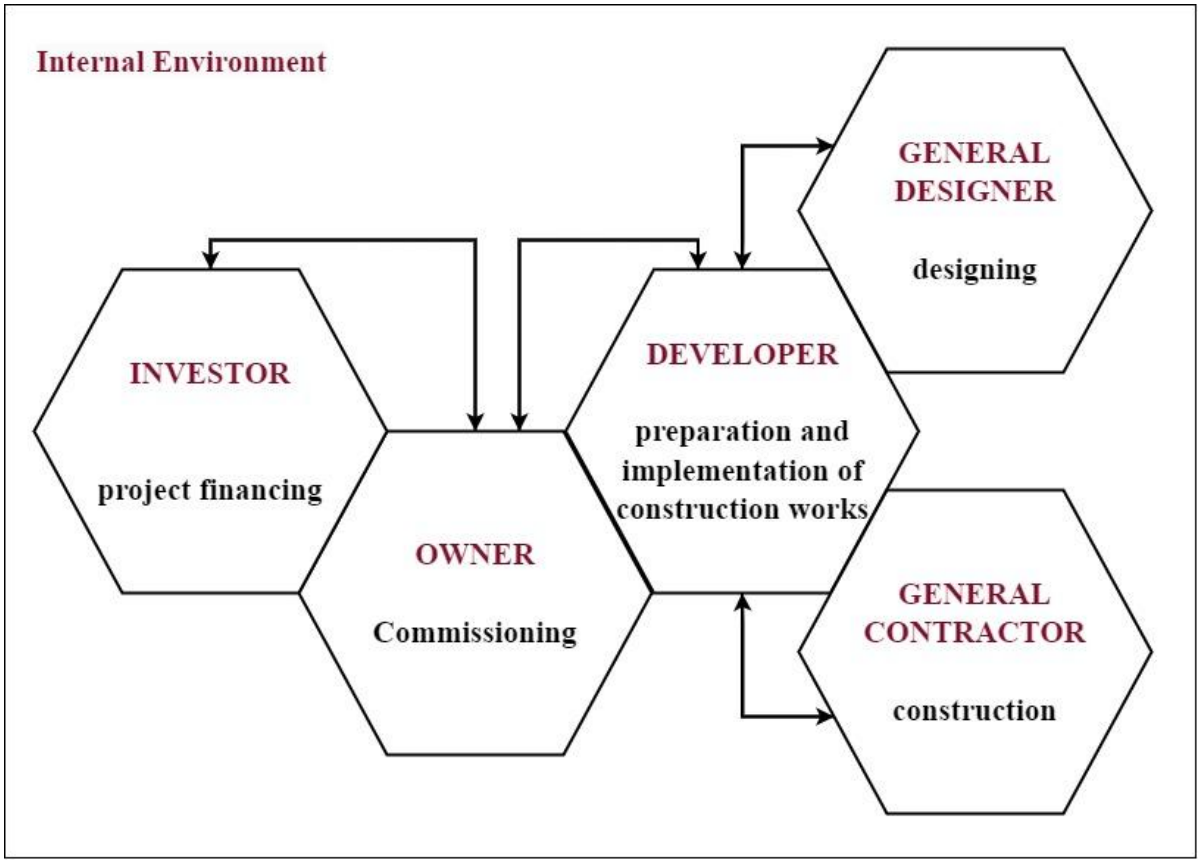

Figure 2.5. - General management structure of a construction company (internal organizational environment)

The international component of the external organizational environment of a construction company includes various aspects that affect its activities and development in the international construction market. This component includes the activities of international markets and competition. Construction companies face competition in the international market with other companies that may have different levels of expertise, resources, and pricing strategies. Standards and regulations may also change occasionally: Companies must comply with international construction standards and regulations, which may differ from country to country. This can be a challenge when doing business internationally. International logistics has a significant impact on this component. Sending materials and equipment across borders can be challenging due to different

countries' various rules and procedures. Inexperience in this case refers to unpredictable changes in legislation, currency risks and instability in the international market.

The political component of the external organizational environment of a construction company covers the influence of political factors on the company's activities and market conditions. The key ones are:

1. Specifics of legislation and regulation. Political decisions and legislative acts may affect licensing procedures, construction safety standards, environmental standards, and other aspects of construction companies' activities.

2. Tax policy. Tax rates, tax refunds, tax incentives and other tax aspects may affect the company's financial performance and competitiveness in the market.

3. Public policy and public relations. Public perception, response to public discussions and cooperation with local authorities may affect the company's reputation and the ability to obtain public support for projects.

4. Regional policy. Regional aspects such as local legislation, election campaigns, infrastructure development and other factors may affect the company's projects in certain regions.

In this case, uncertainties are associated with political, tax risks, risks of changes to legislation and regulation of building regulations, etc.

The economic component of the external organizational environment of a construction company covers various aspects of economic conditions that affect the company's operations and market position. These include the macroeconomic situation, including changes in gross domestic product, inflation, unemployment, etc. Another factor is the cyclical nature of the construction industry, which affects the volume of investments, etc. Uncertainty is associated with economic instability, which can significantly change the landscape of the construction industry in different regions of the world. This environment also includes social and cultural influences that have their own characteristics and affect the formation of projects and diversification strategies in the activities of construction companies.

Thus, we have built a conceptual representation of the structural model of the organizational environment of construction companies, which takes into account the diversification of their activities and is distinguished by the fact that it organically combines the entire range of companies' activities under conditions of uncertainty. The application of such a concept in the activities of companies should improve the quality and success of construction projects and generally increase the productivity of a construction company, despite the numerous uncertainty factors in which it operates.

2.2. Method of forming potential diversification strategies for construction companies

Formulating potential diversification strategies for construction companies can be a complex process that requires analyzing various factors, such as market conditions, financial capabilities, technical abilities, and the company's strategic goals. The success of construction projects and the company's productivity depend on the implementation of diversification strategies. However, before implementing a diversification strategy, it is necessary to evaluate it and understand the impact it will have on the company's development. As described in the previous paragraph, diversification strategies are formed and evaluated in a separate block in the organizational structure.

In order to formulate potential diversification strategies for construction companies, especially in an uncertain environment, it is necessary first to analyze the market in the construction industry. Market research to identify new opportunities and niches that can be occupied. This may include assessing the demand for different types of construction services, identifying market trends, and analyzing competitors. The next step is to assess competitiveness. It involves analyzing the strengths and weaknesses of competitors to identify possible market entry points or segments where the company can have an advantage. After that, it is necessary to formulate a strategy, including developing new products or services

that meet market needs. It can also include expanding the range of existing services, entering new markets (regional, international), establishing new strategic partnerships, investing in developing and implementing modern construction technologies, or improving existing processes to increase the company's efficiency and competitiveness.

This section will discuss the conceptual framework for developing diversification strategies for construction companies. For this purpose, the principles of engineering will be applied and the principles of changes to the organizational structure of a construction company, which were discussed in the previous section, will be taken into account. As mentioned above, such changes in the organizational structure will reduce risks, as construction companies operate in an uncertain environment. The construction company's diversification center will take over formulating, evaluating and implementing diversification strategies.

In the course of its activities, the diversification center performs the following functions:

1. Collecting and analyzing information related to creating the company's diversification strategies. These functions are duplicated in the functions of the analytical department. However, the information related to the formation of diversification strategies is specific and for the successful implementation of this concept the invented center must perform these functions.

2. Conduct a comprehensive assessment of the diversification strategies their economic, technical and other advantages and disadvantages. Based on the selected strategy or strategies, a business plan is developed and integrated into the overall business plan of the construction company.

3. Conducting comprehensive engineering of all components related to the formation, evaluation, selection and organization of the process of implementing diversification strategies of construction companies.

4. Liaison with the analytical and support departments to create and maintain documentation on diversification activities.

The stages of forming diversification strategies are shown in Table 2.1.

Table 2.1.

The concept of formation and implementation of diversification strategies for construction companies based on engineering principles

Stage 1. Formation of requirements for diversification of the construction company
1.1. The requirement to minimize financial risk when implementing a diversification strategy.
1.2. The requirement to increase the return on assets with the existing financial risk.
1.3. The requirement to ensure a positive increase in the assets of the construction company as a result of the potential implementation of the diversification strategy.
1.4. The requirement to ensure an appropriate level of liquidity of the construction company's assets. Optimization of mechanisms and processes of asset turnover.
Stage 2: Assessment of the organizational environment of the construction company and formation of a diversification policy
2.1. Research and analysis of the organizational environment of the construction company, in particular the impact of the external environment under conditions of uncertainty to identify potentially profitable sectors for the implementation of diversification strategies.
2.2. Formation of diversification strategies and formation of their general list in accordance with the tasks and requirements formulated at stage 1.
Stage 3. Building a ranked list of diversification strategies by evaluating them based on data from open sources

	Analysis of the cost of implementing diversification strategies and the economic effect of them, i.e. analysis of real financial flows and net income of the construction company.
	The amount of expenses incurred by the participants in the construction process for taxes, purchase of materials and equipment, and commissioning related to the relevant diversification strategy.
3.1. Comprehensive assessment of construction project diversification strategies by a system of indicators	Number of employees hired to implement the diversification strategy.
	Project capacity for current and non-current assets based on the results of the diversification strategy.
	Calculation of the ratio of the project cost to the value of the invested assets. The calculation should be made no earlier than when the project capacity is more than 70-75%. The cost is determined by expert evaluation.
	The intensity of the development of the invested funds for the implementation of the diversification strategy.
	The amount and intensity of costs for the implementation of the diversification strategy.
3.2. Formation of the final ranked list of diversification strategies. The list is formed according to preferences, where the strategy with the highest score is ranked first, and the strategy with the lowest score is ranked last.	
Stage 4. Building a monitoring system for projects that implement a	

diversification strategy.	
4.1 Formation of a system of criteria for evaluating construction diversification projects and building a list of real projects for diversification by a construction company.	
4.2. Development of a system for evaluating projects in the dynamics, assessing solvency, liquidity of diversification, financial and resource flows based on the criteria data.	
Stage 5. Implementation of the chosen diversification strategy.	
Stage 6. Evaluation of the results of implementing a diversification strategy in a construction project.	
6.1. Evaluation of the results of the diversification strategy implementation according to the indicators used for the comprehensive project diagnostics (clause 3.1.)	
6.2. Evaluation of the results of the diversification strategy implementation by the following indicators	Net working capital ratio
	An indicator of asset liquidity after the end of the diversification program.
	Indicator of social efficiency of a construction project.
	Calculation of the probability of bankruptcy after the completion of the diversification program.
6.3. Assessment of qualitative and quantitative parameters of changes in the assets of the construction company at the	Changes in current assets
	Changes in non-current assets
	Increase in the return on non-current assets

time of completion of the diversification strategy implementation compared to the period before its implementation	Increase in return on equity of non-current assets
	Increase in balance sheet profit for the reporting period.
	Increase in the share of cash flows in the value of assets.
6.4. General assessment of the results of the diversification strategy implementation for the construction company and consideration of this assessment for planning future projects and programs.	

The first stage is the formation of general requirements for the diversification of a construction company. At this stage, general requirements are formulated that must be taken into account at the stage of drawing up the company's diversification strategy. If these requirements are not met, then such a strategy will not be accepted. This stage includes the requirement to minimize financial risk in the implementation of the diversification strategy since the implementation of diversification strategies involves significant financial costs. This stage also includes the requirement to increase the return on assets with the existing financial risk, to ensure positive growth of the construction company's assets as a result of the potential implementation of the diversification strategy, and to ensure an appropriate level of liquidity of the construction company's assets.

At the second stage, the organizational environment of the construction company is assessed and a general diversification policy is formed. The information assessment is based on information from open sources. It emphasizes that the structure of the construction company should include a diversification center. This process is described in paragraph 2.1. At this stage, the organizational environment of the construction company is analyzed, particularly the impact of the external environment under conditions of uncertainty, to identify potentially

profitable sectors for the implementation of diversification strategies. Also at this stage, diversification strategies are formed.

The third stage involves building a ranked list of diversification strategies by evaluating them. A comprehensive assessment of diversification strategies for construction projects involves analyzing the costs of implementing diversification strategies and the economic effect of them, i.e., analyzing the real financial flows and net income of the construction company, analyzing the number of employees involved in the project, calculating the ratio of project cost to the value of invested assets, as well as the cost intensity of the diversification strategy. The stage ends with forming a ranked list of diversification strategies that are suitable for implementation and have advantages according to the selected indicator.

The fourth stage involves building a monitoring system for the project that implements the diversification task. Form a system of criteria for evaluating construction diversification projects and building a list of real projects for diversification by a construction company. The fifth stage is the implementation of the diversification strategy. The results of implementing the diversification strategy in the construction project are evaluated at the sixth stage. The evaluation is based on the indicators used for the comprehensive diagnosis of the project.

For a construction company, the method of forming diversification strategies may include the following steps:

1. Analysis of internal resources and competencies. Before considering possible areas of diversification, it is essential to assess the company's existing internal resources, skills and expertise. For example, if a company has experience in residential construction, it may consider expanding into commercial real estate or infrastructure projects.

2. Market and competitor analysis. Market research to identify new opportunities or niches where the company can take its place. This may include analyzing the demand for different types of construction services, market trends, and competitive analysis.

3. Risk and opportunity analysis. It is important to consider the potential risks associated with any new lines of business and the opportunities they may bring. This may include financial risks, technical limitations, or risks associated with market competition.

4. Choosing a strategic direction of diversification. The company may consider various strategic directions of diversification, such as expanding geographical coverage, expanding the range of services, vertical or horizontal integration, or introducing new technologies or innovations in the construction process.

5. Develop and implement a diversification plan. Once the strategic direction of diversification has been chosen, a detailed implementation plan should be developed, including resources, timelines and success criteria.

6. Monitoring and evaluation of results. After implementing new strategies, monitoring their effectiveness and evaluating the results systematically is important. This allows you to promptly respond to market condition changes and correct strategic mistakes.

There are several traditional methods of formulating diversification strategies for businesses, including construction companies. The key requirement is that their data be collected from open sources. Here are some of them:

1. SWOT analysis. A SWOT analysis identifies the company's strengths and weaknesses (Strengths and Weaknesses) and identifies opportunities and threats (Opportunities and Threats) arising in the external environment. Based on this analysis, the company can determine the areas of diversification that align with its strengths and take advantage of market opportunities.

2. Analysis of the product/service portfolio. This method involves assessing the company's current portfolio of products or services regarding their profitability and potential growth. The company can identify new areas of diversification that complement or expand its existing portfolio.

3. Ansoff's matrix. The Ansoff matrix or the development-penetration matrix is the identification of four possible development strategies: development of

products/services for existing markets, development of new products/services for existing markets, entry into new markets and development of new products/services for new markets.

4. Analysis of market and competitive factors. Market and competitor research can identify new opportunities for development. A thorough market analysis can identify niches or segments that are attractive to the company.

5. Technology and innovation scanning. Taking into account technological and innovation trends can identify new opportunities for development. The company may consider introducing new technologies or developing new products based on innovations.

Formulas 2.1, 2.2, and 2.3 define the choice of construction technology as one of the key strategies for increasing the productivity of a construction company. However, the choice of construction technology is also part of the construction company's diversification strategy. Moreover, the selected selection functions are $C^X : 2^X \to 2^X$, 2^X - set boolean X,

$$X \in \{K, M, P, Z, T, S\} \tag{2.16}$$

can be adjusted so that the choice of construction technology is consistent with the diversification strategy proposed for implementation and the requirements formulated at stage 1 (Table 2.1). However, this may not be enough to choose an effective diversification strategy, and it is necessary to conduct a comprehensive analysis of the company's organizational environment, as well as analyze the competitive environment, identify strengths and weaknesses, and analyze whether the technologies take into account innovative trends that can provide a higher economic effect from the implementation of diversification strategies.

With this in mind, the success of a construction project is analogous to the success of a construction diversification project, with the results of additional analysis of the competitive environment, etc. included in the determination of the selection functions C. Accordingly, the success of a diversification strategy is defined as a weighted assessment of the success of a construction project, taking

into account the overall assessment of the diversification strategy based on open sources, that is

$$\Phi_d = \lambda F_d\left(C_d^K(K), C_d^M(M), C_d^P(P), C_d^Z(Z), C_d^T(T), C_d^S(S)\right) + (1-\lambda)U_d, \quad (2.17)$$

where Φ_d - evaluation of the diversification strategy of a construction company;

$F_d(\ )$ - assessment of the choice of construction technologies, taking into account resource constraints, etc;

U_d - evaluation of the diversification strategy taking into account the competitive environment, etc.;

λ - a weighting factor that determines the priority of the first and second assessments in calculating the overall assessment of the construction company's diversification strategy, $\lambda \in [0,1]$.

If $\lambda = 0$, then this means that in assessing the diversification strategy of a construction company, the main role is played by the general assessment of diversification based on SWOT analysis, or analysis of the competitive environment.

If $\lambda = 1$, then only the assessment of the choice of construction technology is taken into account in the diversification assessment.

The following open sources can be used to obtain technical and economic parameters of the diversification of construction companies' strategies:

1. Financial reports and reports on the activities of companies. Financial reports of public companies published on their websites or in databases may contain information on the financial results of various diversification strategies. This may include data on expenses, revenues, profitability and profitability of different business lines.

2. Analytical reports and studies. Many financial and analytical agencies conduct research and analysis in various industries, including the construction industry. These studies may include an analysis of the technical and economic parameters of construction companies' diversification strategies.

3. Scientific publications and journals. Journals and publications dedicated to the construction industry or strategic management may contain scientific articles and studies that describe the technical and economic aspects of diversification in this industry.

4. National and international statistical agencies. Organizations such as the International Monetary Fund (IMF), the World Bank, and national statistical agencies can provide data and analysis on the development of the construction industry and the diversification of strategies within it.

5. Conferences and exhibitions. Participation in exhibitions, conferences and other professional events can provide an opportunity to learn about new technologies, innovations and strategies used in the construction industry.

6. Expert advice. Contacting specialists or consultants in the construction and strategic management field can also help obtain necessary information and advice on the technical and economic parameters of diversification strategies of construction companies.

When analyzing the organizational structures of construction companies, it is determined that the organizational structure with a diversification center can be effectively used in conditions of uncertainty, and the use of engineering principles will allow for the prompt solution of small tasks and strategic changes in the conditions of the company's operation to obtain more significant economic benefits. It has been found that for the rational operation of a development construction company under conditions of uncertainty, a set of three models is used:

- formation of the organizational environment of the construction company, taking into account the diversification center;

- formation of technical and economic parameters for the preparation of construction to ensure the achievement of the goals of all participants in the construction process: investors, designers, developers, owners, contractors;

- formulation of diversification strategies based on the analysis of the competitive market and considering quantitative estimates of technical and economic parameters to ensure the implementation of diversification strategies. Quantitative estimates must be selected based on the concept of open sources;

- evaluation of diversification strategies and their implementation in the activities of the construction company.

The results obtained from the analysis of the organizational environments of construction companies and the constructed scheme for creating, evaluating and implementing diversification strategies based on the open data concept have the following advantages for construction companies

- the ability to reflect the complex diversification processes and management processes of construction companies under conditions of uncertainty, taking into account engineering;

- the ability to create, evaluate and implement diversification strategies and use a scientifically based choice of optimal diversification strategies aimed at increasing the profits of a construction company, which is especially useful in conditions of uncertainty;

- the scheme provides for sufficient flexibility, i.e. if the management of the construction company is not satisfied with the chosen diversification strategy, it is possible to choose another one from the ranked list;

- increasing the reliability of the analysis of diversification data and the competitive market by using the concept of open data.

Conclusions to chapter 2

1. It has been established that in the conditions of uncertainty in which construction companies operate, it is necessary to change the perception of the organizational environment of a construction company, which consists of internal, external and task environments. These components of one organizational environment were described considering the need to include a

separate component that meets diversification objectives. Thus, as a result of the study, the conceptual representation of the structural model of the organizational environment of construction companies was further developed, taking into account the diversification of their activities and being distinguished by the fact that it organically combines the entire range of activities of companies in conditions of uncertainty.

2. The formal representation of construction technology and the task of choosing construction technology is described. The choice of construction technology, in combination with the analysis of the competitive market and the analysis of technical and economic requirements for the task of diversification, makes it possible to thoroughly approach the formation of diversification strategies for a construction company. As a result of the analysis, the method of forming diversification strategies has been improved, taking into account the analysis of information on the activities of construction companies based on the concept of open sources, which is used to create a list of alternatives in the task of choosing rational diversification strategies for companies and allows expanding the possibilities of managing them.
3. The concept of forming and implementing diversification strategies for construction companies, taking into account the principles of engineering, which takes into account six main stages from the formation of requirements for diversification activities to the evaluation of the results of implementing a diversification strategy in a construction project was described.
4. The list of advantages from the formation of diversification strategies on the new principles is described: the ability to reflect complex diversification processes and management processes of construction companies under conditions of uncertainty, taking into account engineering; the ability to create, evaluate and implement diversification strategies and use a scientifically sound choice of optimal diversification strategies aimed at

increasing the profits of a construction company, increasing the reliability of the analysis of diversification data and competitive

CHAPTER 3. EVALUATION METHOD AND DECISION-MAKING MODEL FOR CHOOSING RATIONAL DIVERSIFICATION STRATEGIES FOR CONSTRUCTION COMPANIES

3.1. General model of multicriteria decision-making for choosing rational diversification strategies for construction companies

Suppose there is a construction company B whose main activity is the creation of real estate objects and the organization of relevant processes during construction. The organizational structure, peculiarities of the company's activities and the history of creating projects and construction objects are known. We will also assume that the company's activities are carried out under conditions of uncertainty and risk. Suppose that a study of the activities of Company B revealed that diversification measures should be implemented to increase profits and reduce risks. A set of diversification strategies or permissible alternatives was formed.

$$S = \{s_1, s_2, \dots s_n\}, \tag{3.1}$$

that can be implemented by the company, i.e., company B has sufficient financial and human resources for this, n is the number of possible diversification strategies. Since we are considering a finite-dimensional multicriteria problem, we will consider the vector criterion for evaluating strategies

$$c(s) = (c_1(s), c_2(s), \dots, c_m(s)), \tag{3.2}$$

$s \in S$, m – number of criteria for evaluating alternatives. Each of the criteria can have a weight $w_1, w_2, \dots w_m$, determining the importance of each criterion in the evaluation of alternatives, $\sum_{i=1}^{m} w_i = 1$.

The aim of the study is to determine a rational diversification strategy from the set of acceptable alternatives

$$s_j^* \in \{s_1, s_2, \ldots s_n\},\ j = \overline{1,k},\ k < n \tag{3.3}$$

over a given criterion space, taking into account uncertainty. Moreover, the result of the method can be either one rational diversification strategy or an ordered set of strategies

$$\{s_1^*, s_2^*, \ldots s_k^*\}. \tag{3.4}$$

The evaluation and implementation of appropriate diversification strategies will simplify the identification of risks and facilitate the timely adjustment of the construction company's activities in the face of uncertainty.

Choosing the best or rational solution is a traditional approach to rationalizing the schemes of choosing alternatives in the activities of a construction company. For this purpose, three options are often considered

$$\{S, O, R\}, \tag{3.5}$$

where S – set of alternatives, P – principles of optimality or rationality, R – conditions of selection and results of alternative selection. It is clear that in order to find a solution to the problem of choosing or ranking alternatives, it is necessary to apply the multicriteria analysis apparatus, and it is necessary to take into account, first of all, the methods of multicriteria decision-making used in conditions of uncertainty.

In this case, there are three main stages in the decision-making process:

1. Detailed identification and description of diversification strategy alternatives and criteria for selecting rational alternatives.

2. Carrying out numerical calculations based on the selected method of multicriteria analysis, taking into account the weights of the criteria to determine the appropriate assessments of alternatives.

3. Processing of the obtained estimates to select a rational alternative or ranking of alternatives in order of preference for implementation in accordance with the described set of criteria.

The core of the classical multicriteria decision-making problem is represented by a decision matrix:

	c_1	c_2	…	c_m
	w_1	w_2	…	w_m
s_1	e_{11}	e_{12}	…	e_{1m}
s_2	e_{21}	e_{22}	…	e_{2m}
⋮	⋮	⋮	⋱	⋮
s_n	e_{n1}	e_{n2}	…	e_{nm}

where s_j – diversification strategies, $j=\overline{1,n}$, c_i – criteria, w_i – weighting coefficients of the criteria, $i=\overline{1,m}$, e_{ij} – Evaluation of diversification strategies according to certain criteria. That is, estimates are functions of

$$e_{ij}=c_i\left(s_j\right). \tag{3.6}$$

If $I=\{1,2,\ldots,m\}$ – the set of all indices, $I^+=\{1,2,\ldots,p\}$ – is the set of indices of the objective functions to be maximized, a $I^-=\{p+1,p+2,\ldots,m\}$ – is the set of indices of the objective functions to be minimized, $I=I^+\cup I^-$. Then the problem can be written as follows:

$$\sum_{i\in I^+} w_i' c_i(s)\to\max, \tag{3.7}$$

$$\sum_{i\in I^-} w_i'' c_i(s)\to\min, \tag{3.8}$$

$$\sum_{i\in I^+} w_i'=1,\ \sum_{i\in I^-} w_i''=1,\ s\in S. \tag{3.9}$$

Therefore, to solve the problem of making a multicriteria decision, in particular, selecting or ranking diversification strategies for construction companies, it is necessary to develop a multicriteria method or methods of decision-making that would satisfy the conditions:

1. Methods should provide adequate results under conditions of uncertainty.

2. Evaluation criteria and alternatives should adequately reflect the complex diversification processes in the activities of construction companies.

3. The ability to adapt the methods or to use other decision-making methods, as well as to export results from one method to another, which would allow to confirm or refute the results of the assessment.

4. Simplicity and clarity in interpreting the results of the assessment of alternatives, i.e., the creation of appropriate scales and descriptions of the assessment results, which would facilitate the work of the decision maker.

5. The ability of the decision maker to choose other alternatives if the proposed ones do not suit him/her. This is ensured by introducing clear preferences between alternatives.

6. The choice of alternative should be consistent with the resource, in particular financial and human, capabilities of the construction company.

7. Use of methods for tasks with a significant number of strategies and evaluation criteria. The ability to link the results obtained from the application of multi-criteria analysis methods to the company's diversification goals, including performance parameters, quantitative and qualitative indicators. This allows for dynamic monitoring of the implementation of diversification strategies, adjusting them if necessary.

Using these requirements, a multi-criteria decision-making method can be developed to select a rational strategy or strategies for diversification of a construction company. This method should be based on a set of criteria, taking into account resource provision. It is also possible to develop an appropriate information technology, which, when implemented, will increase the efficiency of the enterprise in terms of increasing profits in the medium and long term and reduce the risks of operating under conditions of uncertainty.

It should be noted that the successful implementation of information technology for evaluating a company's diversification strategies is only one component of its effectiveness. Among other things, the following performance results should be taken into account:

1. Reformatting and improving the concept of forming the structure and scope of work in the organization of construction and implementing a diversification strategy.

2. Adaptation of technologies and specifics of activities, in particular, the peculiarities of the organization of relations between suppliers, customers, and stakeholders of the company, taking into account the implementation of a rational diversification strategy.

3. Possibility of changing or adjusting the organizational structure as a result of the implementation of the roadmap for the diversification strategy.

4. Ability to change the technical and economic parameters of construction and other activities in accordance with the requirements of the participants in the construction process based on the peculiarities of the implementation of diversification measures.

3.2. A model for choosing diversification strategies for construction companies based on the assessment of construction parameters

As mentioned in Section 2, the task of forming, evaluating and implementing diversification strategies involves the formation, justification and selection of construction technology, selection of construction parameters, assessment of the competitive environment and other components that influence the choice of a diversification strategy. In the end, the problem of choice is solved, which allows to form a ranked list of diversification strategies that can be implemented in the activities of a construction company.

The task of choosing construction technologies was discussed in section 2. In this section, we will consider the method of selecting construction parameters to form a rational diversification strategy. We will consider this process on the example of horizontal integration.

Let the set of construction parameters be given

$$a_1, a_2, \ldots, a_s, \tag{3.10}$$

where s – number of parameters, each of which is evaluated by a set of criteria

$$g_1, g_2, \ldots, g_k, \tag{3.11}$$

where k – number of evaluation criteria.

Also, the decision maker should be involved in the process of selecting the parameters. In addition, all the parameters under consideration are part of the requirements for the implementation of specific diversification strategies of the construction company, primarily horizontal diversification. For example, the company was engaged in non-business construction and decided to diversify and expand its activities by launching projects for the construction and commissioning of residential buildings. The decision-maker may be a representative of the diversification center, which is envisaged in the new structure of the construction company. It is important that the parameters $a_1, a_2, \ldots, a_s$ reflected realistic estimates of various components of the respective diversification strategies and did not contradict each other. The list of these parameters is formed by the diversification center for a specific diversification strategy. Although the approach to the formation of construction parameters may be universal, since economic conditions are changing rapidly and the risk of environmental impact on the construction system is increasing, it can be concluded that such a list of parameters should be formed under a separate diversification strategy for a particular company, taking into account resource constraints, etc. That is why a separate diversification center should be provided in the structure of companies.

So, let's consider the process of forming building parameters considering the horizontal integration of a company that has moved from non-residential to residential construction. Parameters such as total area, living space, ratio of living space to total area, building area, and floor height are determined by the customer's basic requirements for the building. The parameters of comfort, environmental friendliness, quality and flexibility of the building plan, and the choice of materials that are easily repairable determine the adaptive potential of the building. All other

characteristics - energy efficiency, material consumption, labor costs, number of employees at different stages of construction, cost and duration of construction and installation works - determine the manufacturability, i.e. a set of solutions for the planning and construction of residential buildings that meet the requirements and standards. Two optimality criteria were chosen to solve the problem: minimizing and maximizing scores, depending on the content. That is, all construction parameters will be divided into two blocks depending on the task of maximization or minimization. The parameters to be maximized in the task are: total area, living space, comfort, environmental friendliness, flexibility of the building plan. The parameters to be minimized are: building area, energy intensity, material intensity, labor costs, cost of construction works, duration of construction works.

Table 3.1 shows a scale for assessing the construction parameters of a particular diversification strategy.

Let B diversification strategies be given

$$D = \{D_1, D_2, \ldots, D_B\} \tag{3.12}$$

i N experts who evaluate construction parameters to formulate these strategies:

$$E = \{E_1, E_2, \ldots, E_N\}. \tag{3.13}$$

The maximization set of construction parameters of the diversification strategy d and the set of experts' estimates of the parameters are given in the form:

$$\overline{G}_d^e = \left\{E^e\left(Z_d\right), E^e\left(H_d\right), E^e\left(K_d\right), E^e\left(I_d\right), E^e\left(R_d\right)\right\},\ d = \overline{1,B},\ e = \overline{1,N}, \tag{3.14}$$

where Z_d - total building area, $Z_d \in R$, $E^e\left(Z_d\right)$ - estimate of the total building area for strategy d from expert e. In general, the larger the building area, the more money the project investor will be able to receive, so this indicator is maximized. H_d - total area of residential development, $H_d \in R$, $E^e\left(H_d\right)$ - Estimation of the residential building area for strategy d by expert e. Comfort

$E^e(K_d)$, environmental friendliness $E^e(I_d)$ and flexibility of the building plan $E^e(R_d)$ - subjective indicators determined by an expert e.

Table 3.1.

Scale for assessing construction parameters for a given diversification strategy

#	**Priority assessment**	**Verbal assessment**	**Points**
1	The highest	The parameter is very important for the construction process participant. Without its consideration, in the opinion of the construction process participant, it is impossible to effectively implement the process.	(21-25]
2	High	The parameter is important for the construction process participant and its consideration is key in the construction process.	(16-21]
3	Medium	The parameter is of medium importance in the opinion of the construction process participant. It should be considered, but there are more important options.	(11-16]
4	Low	The parameter has a low priority for the construction process participant. It is likely to be considered, but not considering it will not significantly affect the construction process.	(6-11]
5	Very low	The option has a very low priority. It is not important for the construction	[1-6]

		stakeholder to consider it or not.	

The minimizing set of construction parameters of the diversification strategy d and the set of experts' estimates of the parameters are given in the form:

$$\underline{G}_d^e = \left\{ E^e\left(P_d\right), E^e\left(Y_d\right), E^e\left(M_d\right), E^e\left(V_d\right), E^e\left(J_d\right), E^e\left(C_d\right) \right\}, d = \overline{1,B}, e = \overline{1,N} \quad (3.15)$$

where

P_d - total area of the land plot, $P_d \in R$,

$E^e\left(P_d\right)$ - estimate of the total land area for strategy d from expert e,

Y_d - energy intensity of construction, $Y_d \in R$,

$E^e\left(Y_d\right)$ - assessment of the energy intensity of construction for strategy d by expert e. The energy intensity (kWh/m³) should be minimal to reduce the consumption of raw materials for heat and electricity production, so this parameter is minimized.

M_d - material intensity of construction or the ratio of total material costs per unit of output, $Y_d \in R$,

$E^e\left(M_d\right)$ - assessment of the material intensity of construction for strategy d by expert e,

V_d - construction cost, $V_d \in R$, $V_{min} \le V_d \le V_{max}$,

$E^e\left(V_d\right)$ - estimate of construction costs for strategy d from expert e. The cost is capped at the top and bottom for each diversification strategy and construction object,

J_d - cost of employee labor, $J_d \in R$, $J_{min} \le J_d \le J_{max}$,

$E^e\left(J_d\right)$ - expert e's estimate of the cost of employee labor for strategy d should be minimized.

C_d - duration of construction and installation works, $C_d \in R$, $C_{min} \le C_d \le C_{max}$,

$E^e\left(C_d\right)$ - the estimate of the duration of construction and installation works for strategy d from expert e should be minimized.

Numerical points

$$G_d^e = \overline{G}_d^e \cup \underline{G}_d^e, \tag{3.16}$$

according to the scale (Table 3.1) are assigned by experts e and entered into a separate table. Next, the total scores for each construction parameter for each diversification strategy are calculated, i.e.

$$X_d = \left\{Z_d, H_d, K_d, I_d, R_d, P_d, Y_d, M_d, V_d, J_d, C_d\right\} \tag{3.17}$$

and

$$E\left(x^d\right) = \sum_{i=1}^{N} E^i\left(x^d\right),\ x^d \in X_d,\ d = \overline{1,B} \tag{3.18}$$

$$E\left(x^d\right) = \frac{E\left(x^d\right)}{N},\ d = \overline{1,B}, \tag{3.19}$$

where $E\left(x^d\right)$ - assessment of construction parameters for diversification strategies $d = \overline{1,B}$ for each of the evaluation categories for all experts.

General assessment of diversification strategies $d = \overline{1,B}$ will look like:

$$\Lambda^d = \frac{\sum\limits_{x^d \in X_d} E\left(x^d\right)}{\operatorname{card}\left(X_d\right)}, \tag{3.20}$$

where Λ^d - evaluation of diversification strategies $d = \overline{1,B}$.

These scores are the basis for applying multi-criteria decision-making to select a specific diversification strategy for a construction company. The diversification strategy that receives the highest score is the optimal one for implementation, i.e.

$$d^* = \arg\max\left\{\Lambda^d\right\},\ d = \overline{1,B} \tag{3.21}$$

where d^* - optimal diversification strategy for implementation in the construction company's activities. All other strategies are arranged in descending order of score Λ^d and a ranked list of rational strategies by preference is generated.

In this example, horizontal integration was considered, so if the type of diversification changes, approaches to evaluating and formulating optimal strategies may change.

3.3. Method for assessing diversification strategies of construction companies

The method of assessing the diversification strategies of construction companies is used before applying the model for choosing rational diversification strategies. It consists in expert evaluation of the most important technical and economic parameters of construction. This is described in paragraph 3.2. However, in this paragraph we will consider the method of evaluating diversification strategies on the example of a specific construction company, China Construction Corporation (CCC). The name has been anonymized because the company, cooperating with Yancheng Politechnic College in research construction projects, did not permit to disseminate information on its diversification strategies' economic and technical components. This is due to the confidentiality of the diversification policy, as diversification concepts aim to overcome competitors' influence. Leaking information on further diversification steps could affect the success of construction projects and the performance of the construction company.

We had data on CCC's activities from 2010 to 2023 to conduct the analysis. Until 2010, the company was engaged in constructing non-residential real estate in Jiangsu Province (People's Republic of China). In 2019, the company created a new diversification sector, whose team, having studied the market, proposed four diversification strategies (horizontal integration) that could, in the opinion of the management, increase the company's competitiveness and productivity. The

strategies concerned four residential complexes, each with its own construction characteristics, location, area, etc. However, the amount of funding that the diversification center team had budgeted prevented the implementation of all four strategies. The first strategy cost $33.5 million, the second - $42.7 million, the third - $55.4 million, and the fourth - $56.8 million.

To evaluate the diversification strategies, the described evaluation method and decision-making model for choosing a rational strategy were applied. To do this, a team of experts was assembled, representing the owner, general designer, general contractor, investors, and other participants in the construction process. A preliminary analysis of the projects was conducted and, based on this analysis, the experts were asked to evaluate the strategies according to the following categories

$$X_d = \{Z_d, H_d, K_d, I_d, R_d, P_d, Y_d, M_d, V_d, J_d, C_d\},\ d = \overline{1,4} \qquad (3.22)$$

1. Z_d - total building area.
2. H_d - total building area.
3. K_d - comfort.
4. I_d - environmental friendliness.
5. R_d - flexibility of the building plan.
6. P_d - total area of the land plot.
7. Y_d - energy intensity of construction.
8. M_d - material intensity of construction or the ratio of total material costs per unit of output.
9. V_d - construction costs.
10. J_d - the cost of employee labor.
11. C_d - duration of construction and installation works.

The scores were based on a scale of 3.1. All experts were divided into five groups and the scores were chosen as the average scores in the code group:

developers E_1, owners E_2, investors E_3, general contractors E_4, general designers E_5. The results are shown in Table 3.2.

According to the results of the survey, according to the scale (Table 3.1), strategies D_1 and D_4 received an overall average score, and strategies D_2 and D_3 received an overall high score, $\Lambda^1 = 15,4$, $\Lambda^2 = 17,2$, $\Lambda^3 = 16,3$, $\Lambda^4 = 13,4$.

Table 3.2.

Expert opinions on the choice of diversification strategies

#	**Groups of experts (participants in the construction process)**					**Average score for each parameter**
	E_1	E_2	E_3	E_4	E_5	
Diversification strategy D_1						
1	11,6	11,9	10,1	17,4	18,9	14,0
2	13,6	13,6	17,8	18,7	19,7	16,7
3	15,5	15,0	19,8	20,1	21,9	18,5
4	14,3	17,4	17,3	18,9	21,1	17,8
5	10,4	9,7	9,9	10,6	12,2	10,6
6	20,1	23,2	22,3	20,1	19,7	21,1
7	19,8	20,0	22,4	22,1	21,8	21,2
8	9,5	9,9	11,5	11,8	11,4	10,8
9	15,8	19,8	14,6	13,0	13,4	15,3
10	15,7	15,4	15,9	17,6	17,9	16,5
11	5,6	6,9	7,1	7,2	8,5	7,1
Diversification strategy D_2						
1	12,8	12,4	11,7	14,8	19,5	14,2
2	14,7	14,9	17,4	19,0	21,7	17,5

3	16,8	16,0	18,4	20,2	20,1	18,3
4	13,7	15,3	16,4	17,4	17,0	16,0
5	15,8	15,9	16,3	16,2	17,8	16,4
6	20,9	23,5	21,8	22,0	20,0	21,6
7	18,9	20,9	21,8	21,7	20,9	20,8
8	11,8	11,8	12,4	13,9	13,1	12,6
9	15,0	17,9	18,9	20,4	21,0	18,6
10	18,1	18,0	19,6	19,7	20,8	19,2
11	13,8	14,7	13,5	13,1	14,0	13,8
Diversification strategy D_3						
1	13,5	12,7	12,7	14,9	19,5	14,7
2	15,8	13,7	16,9	18,6	20,1	17,0
3	16,8	16,8	16,4	16,3	17,5	16,8
4	13,8	14,1	14,0	15,8	17,0	14,9
5	15,0	15,8	16,6	16,8	17,8	16,4
6	20,6	20,1	19,5	19,7	20,5	20,1
7	18,0	18,1	19,6	20,1	20,2	19,2
8	13,6	13,2	12,9	12,7	13,9	13,3
9	16,2	16,0	15,4	15,3	17,0	16,0
10	18,6	17,9	17,3	18,3	19,6	18,3
11	12,4	11,1	12,2	13,0	13,0	12,3
Diversification strategy D_4						
1	12,8	12,3	11,9	11,1	13,9	12,4
2	15,8	15,6	16,6	16,3	17,9	16,4
3	15,8	16,9	16,4	16,6	17,1	16,6
4	12,8	12,2	13,0	11,1	10,9	12,0

5	13,9	13,3	12,0	12,9	11,5	12,7
6	14,8	14,9	14,4	15,0	15,1	14,8
7	15,9	13,9	13,2	12,8	11,4	13,4
8	9,9	10,4	10,1	9,0	9,8	9,8
9	11,8	11,6	12,9	12,4	13,3	12,4
10	14,2	14,9	13,1	13,2	16,5	14,4
11	13,0	13,5	13,0	12,5	12,4	12,9

Since the second diversification strategy had the highest score, it was taken as a basis. The project implementation began in March 2020 and ended in December 2021. The company's real profits for the period from 2010 to 2023 were determined (Fig. 3.1). We also calculated the company's profits after 2020, which were obtained as a result of forecasting without taking into account the implementation of the chosen diversification strategy, i.e. before the strategy was implemented (Fig. 3.2). Both results are shown in Fig. 3.3. As we can see, at first, there was a decline in profits due to an increase in the cost of implementing the diversification strategy D_2, but as of 2023, there was an increase. Thus, it was possible to obtain a profit as of 2023, which exceeds the forecasted figures by 11.1%.

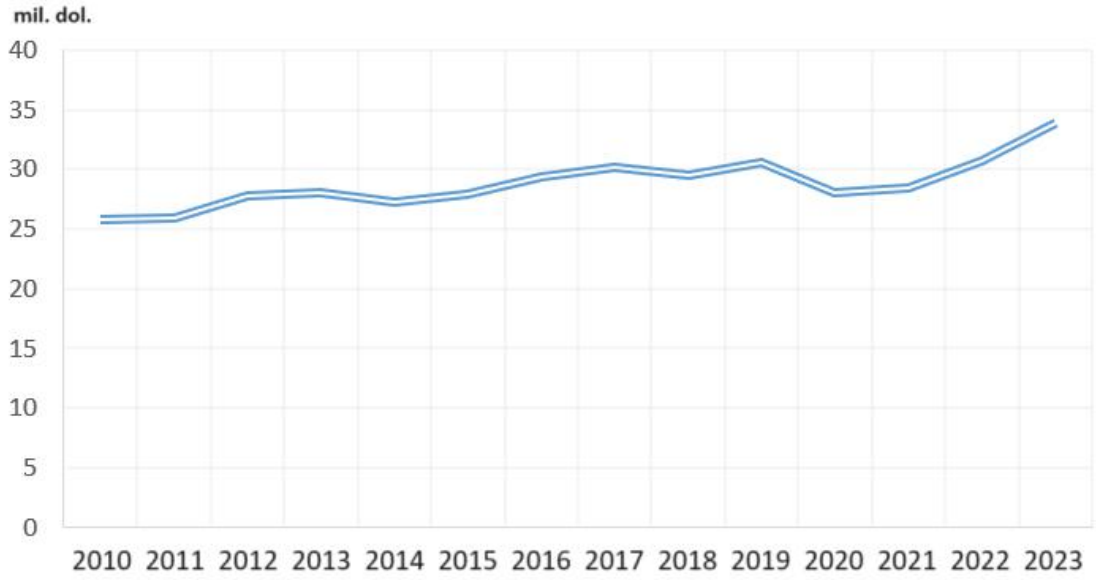

Figure 3.1 - CCC's profit for the period from 2010 to 2023.

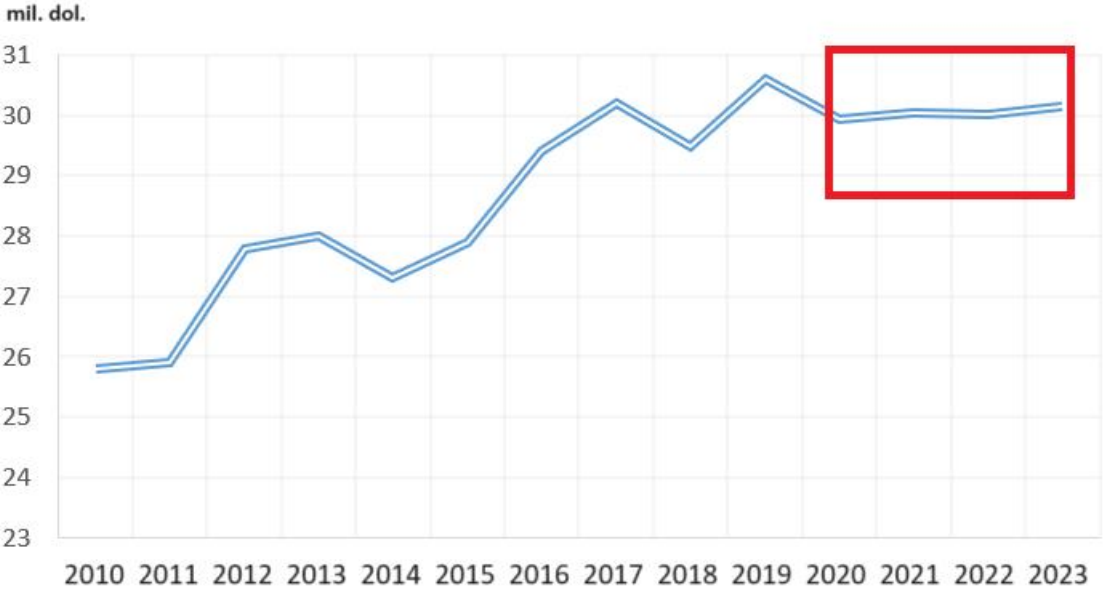

Figure 3.2 - CCC's profit forecast from 2020 to 2023 without taking into account the implementation of the chosen diversification strategy

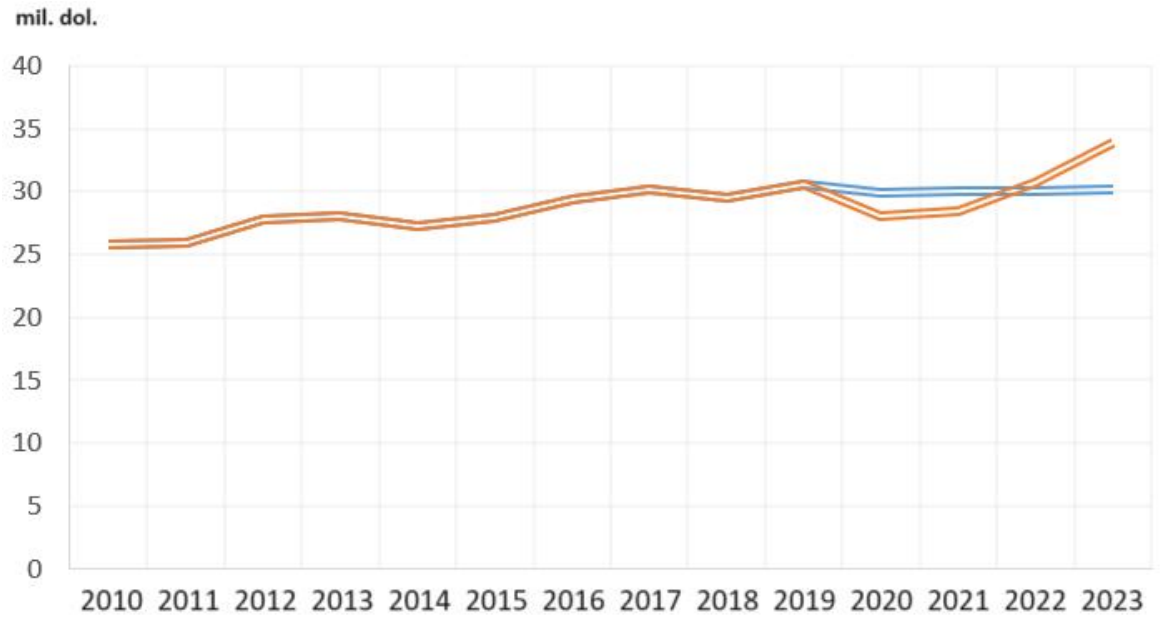

Figure 3.3 - CCC's profit forecast from 2020 to 2023 without taking into account the implementation of the chosen diversification strategy (blue curve), the company's actual profit is the orange curve.

The amount of real profits is shown in Table 3.3. The profit forecast was made using the formula:

$$\hat{q}_n = \left(\sum_{i=1}^{p} i \right)^{-1} \cdot \sum_{j=1}^{p} \left(j \cdot q_{n-p+j} \right), \tag{3.23}$$

where q_n – the projected amount of profit as of a certain reporting period, q_{n-1} – the actual amount of profit recorded at a point in time prior to the current point in time, $\hat{q}_n$ - assessment of the profit forecast over time p. In this task, the value of the period $p = 5$.

Table 3.3. CCC's profit for the period from 2010 to 2023.

Reporting period	Profit in mln. dol.
2010	25,80
2011	25,90
2012	27,80
2013	28,00
2014	27,30

2015	27,90
2016	29,40
2017	30,20
2018	29,50
2019	30,60
2020	28,10
2021	28,50
2022	30,70
2023	33,90

Thus, it is shown that this method of assessing the diversification strategies of construction companies, which is distinguished by taking into account changes in the structure of the organizational environment of companies, allows to increase the efficiency of company management and obtain potentially higher profits.

Conclusions to chapter 3

1. The general task of multi-criteria selection of diversification strategies for construction companies was described, which can be used in conditions of uncertainty when the external environment influences the company's activities: technological changes, political, economic and other factors. The lack of information on implementing new company development strategies creates an urgent need to find methods to improve the efficiency of company management, particularly in terms of diversification of activities, and, accordingly, increase profits.
2. The model for selecting rational diversification strategies for construction companies based on an expert assessment of the technical and economic parameters of construction was described., which takes into account the most significant indicators and allows taking into account the preferences of participants in the construction process. These preferences and the specifics of diversification strategies are incorporated into the indicators by the diversification center to be established in the construction

company. Since this task is complex and requires a separate team of experts, if it is impossible to create such a center within the structure of the construction company, it is necessary to involve a consulting company that deals with this problem.

3. The method for assessing the diversification strategies of construction companies has been improved, which is distinguished by taking into account changes in the structure of the organizational environment of companies and allowing for more efficient management. This method is based on expert evaluation and considers the opinions of all participants in the construction process: owners, developers, investors, general contractors and general designers.
4. The method described for assessing the diversification strategies of construction companies has been verified using the example of a construction company in the People's Republic of China. The results showed a positive economic effect from evaluating and implementing the diversification strategy chosen by the experts.

CHAPTER 4. INFORMATION TECHNOLOGY FOR EVALUATION AND SELECTION OF DIVERSIFICATION STRATEGIES FOR CONSTRUCTION COMPANIES UNDER UNCERTAINTY

4.1. Information technology modules and processes for evaluating and selecting diversification strategies for the task of managing construction companies

Information technology processes include the methods and procedures used to collect, process and manage information, including software development, network administration and others. The information technology processes for assessing and selecting diversification strategies for construction companies include the following steps and actions: data collection and analysis, use of analytical tools, assessment of strengths and weaknesses, development of diversification strategies, evaluation of diversification strategies, decision-making based on the results of the evaluation of diversification strategies or selection of the optimal diversification strategy, as well as implementation and control. Let's take a closer look at these processes.

The first process to be mentioned and, accordingly, the first module of the information system for evaluating and selecting diversification strategies is the data collection and analysis model. This module includes collecting information from open sources about the company's activities and its competitive environment. This information primarily concerns technological, international, political, social and economic components. Information about the technological component of the construction company and its competitors includes the collection of information about the technologies that determine the company's development and its functioning. This item includes construction technologies that determine the quality and efficiency of construction. The emergence of new construction technologies and their use by competitors may mean that other companies have

discovered new ways of technological diversification and if they successfully use these technologies, they may be effective and the construction company should consider adopting the experience of competitors. Another component that is analyzed in the public domain is the use of information technology by other companies: special business software, software for managing construction projects, human resources management, etc. The task is to analyze which software and hardware are used and what effect they have.

It should be noted that almost all construction companies use BIM technologies to increase the efficiency of construction project management and improve coordination between all participants in the company's construction process. However, this is one of the items that the system needs to collect information about. Information should also be collected on the use of robotics and Internet of Things technology in the operation of buildings. Of particular interest is competitors' use of energy-efficient technologies. This is important not only to ensure the stability and profitability of the construction company, but also has important social implications, as the use of such technologies guarantees the state's energy sustainability, reduction of emissions and energy consumption. If competitors use such technologies, the construction company should consider the possibility of developing such technologies on a horizontal level as one of its diversification strategies.

Information on the international activities of competitors is also a separate component of the information collection and analysis module. This item includes competitors' international partners, the company's foreign stakeholders, and international logistics, if any. International logistics can affect pricing, availability of resources, etc. Information is also collected on the specifics of legislation and regulation, tax policy, regional policy, and everything that, from a political and economic point of view, can affect the development of a construction company in a competitive environment under conditions of uncertainty. In particular, inflation, unemployment, employment in the construction industry, interest in the company's products, etc.

After collecting information, it is necessary to analyze it. This is the responsibility of the diversification center team. The team can conduct a SWOT analysis for this purpose. A SWOT analysis involves assessing the company's strengths and weaknesses, as well as opportunities and threats in the external environment, to determine the best diversification strategies. The analysis can also use various methods of data analysis and forecasting models to identify potential diversification strategies and their effectiveness. The Diversification Center team creates a list of diversification strategies

$$D = \left(D_1, D_2, \ldots, D_n\right). \tag{4.1}$$

As a rule, these are several strategies that constitute a full-fledged business plan that takes into account the costs of resources, financial and human resources that need to be attracted to implement the relevant diversification strategy from the conception to the final stage when the diversification strategy is implemented and produces economic effect. The diversification strategy should also consider possible risks that may arise during implementation and afterwards. Diversification strategies should fit into the environment of tasks in the organizational structure of the construction company.

The next module of information technology and the corresponding process is to organize a questionnaire and survey the preferences of the construction process participants regarding the implementation of the relevant diversification strategy, including its components. Suppose we are discussing horizontal integration and a strategy involving investing in constructing a residential complex. In that case, experts are asked to indicate such preferences in a point system:

- estimation of the total area of the land plot to be allocated for construction, which is in line with the defined strategy D_i, $i = \overline{1,n}$;
- assessment of the energy intensity of a construction project that is in line with the strategy D_i;
- assessment of the material intensity of a construction project that meets the strategy D_i;

- estimating the cost of a construction project that meets the strategy D_i;
- estimating the cost of employee labor in a construction project that meets the strategy D_i;
- assessment of the duration of construction and installation works;
- estimation of the total building area that is in line with the strategy D_i;
- estimation of the residential building area for the strategy D_i;
- assessment of the comfort of the construction plan;
- assessment of the environmental friendliness of the construction plan;
- assessment of the flexibility of the building plan.

Next, diversification strategies are evaluated $D = (D_1, D_2, \ldots, D_n)$ based on the method described above. The results are entered in the table (Table 3.2). Next, the scores are calculated and a ranked list of diversification strategies is constructed in descending order of the total score. That is, the strategy with the highest score will receive the first place. Next, the management of the construction company considers the proposals made by the diversification center and may decide to implement the developed diversification strategy. To implement it, a business plan should be written in detail, describing all the resources and financial costs during the project implementation. Table 4.1 describes the possible processes of the technology for assessing and selecting a diversification strategy for construction companies. Let's take a closer look at the methods used to perform these processes.

To collect data from the Internet, the diversification center can use:

1. Web Scraping.
2. Application Programming Interface.
3. Manual data collection.
4. Use of existing data and databases.

Web scraping is the process of automatically collecting data from websites. This process consists of programmatically accessing the content of web

pages and then analyzing and extracting the necessary information from these pages for further use or analysis. First, the program accesses the web server and retrieves the HTML code of the web page. This can be done using an HTTP request. The received HTML code is analyzed to determine the page's structure and find the places where the target information is located. After analyzing the HTML code, the program extracts the necessary information from various page elements, such as text, tables, images, etc. This may include using regular expressions, CSS selectors, or XPath to localize the required data. Once the data is extracted, it can be processed and saved to a suitable format, such as a text file, database, or table. Web scraping can be an automated process performed regularly to update data or collect information from many pages of the same website or different websites.

Table 4.1.

Processes of technology for assessing and selecting a diversification strategy for construction companies

Process number	Task name	Performer / responsible	Method
1	Data collection and analysis	Diversification center	Method of collecting open data from the Internet
2	Formation of diversification strategies	Diversification center	Method of forming diversification strategies, SWOT analysis, analytical tools, scenario development
3	Evaluation of diversification strategies	Diversification center	A method for evaluating diversification strategies
4	Decision-making	Management of the construction company	Method of selecting a diversification strategy for implementation, implementation and monitoring of implementation
5	Evaluation of	Analytical	A method for evaluating

	results	Department, Diversification Center	the results of implementing a diversification strategy

An Application Programming Interface (API) is a set of rules and protocols defining how programs can interact. An API allows developers to access functions or data from another program or service without knowing the details of their implementation. An API defines a set of functions and data available for interaction. This can be anything from data processing methods to performing certain operations. An API defines how programs can communicate with each other. This can include data transfer formats such as JSON or XML and network communication protocols such as HTTP or TCP/IP. An API may include authentication and authorization mechanisms that ensure the security of the interaction between applications. This may include using access tokens, API keys, and other user identification methods. Many APIs provide documentation and use cases explaining how to use the API and interact with it. This feature allows you to use data from sites about the characteristics necessary for analysis and data collection that can help formulate optimal diversification strategies.

Manual data collection from websites is when a Diversity Center staff member manually browses web pages and records the necessary information. This method can be used where automated data collection is not possible or efficient. Before starting manual data collection, it is essential to determine which websites will be used as sources of information. These can be competitors' websites, market portals, news resources, and any other sources that contain important information to you. Before you start collecting data, it is essential to clearly define what kind of information you are looking for and what criteria you need to consider when collecting it. Once you have identified the sources and criteria, go to the websites and browse their pages. Once you have collected enough data, it is important to analyze it. Evaluate your collected information, highlighting key information and trends you've discovered. The information obtained during manual data collection can be useful in formulating diversification strategies. It can help you understand

the market, the competitive environment, customer needs, and other aspects that may affect your strategies. While manual data collection can be time-consuming and labor-intensive, it can be very useful when automated data collection is impossible. It can provide important information for strategic decision-making when formulating sound diversification strategies.

The use of existing data and databases can significantly facilitate the process of formulating rational diversification strategies for a construction company:

1. Analysis of historical data. Any construction company has historical data on its activities, such as costs for various projects, lead times, quality of work, etc. Analyzing this data can help identify successful and unsuccessful projects and trends and factors affecting performance. Based on this analysis, diversification strategies can be developed to improve efficiency and reduce risks.

2. Study of market data. In addition to its own data, the company may access market data, such as supply and demand in the construction services market, price dynamics, consumption trends, etc. Analyzing this data will help to understand the needs and preferences of customers, identify possible niches for development and determine the best areas for diversification.

3. Use of competitor data. Data on competitors, their projects, strategies and results can be valuable information when formulating diversification strategies. By analyzing this data, a company can identify its competitive advantages and disadvantages and find new opportunities for development and differentiation.

4. Assessment of internal resources. Already existing databases may also contain information about the company's internal resources, such as personnel qualifications, technical capabilities, material and technical base, etc. This information can be used to assess the company's internal strengths and identify expansion opportunities.

In general, using existing data and databases facilitates formulating

rational diversification strategies, helping a company better understand its internal and external factors affecting the business and make informed decisions.

Once the data has been collected, it must be analyzed using methods that will allow to identify those characteristics that may be significant in forming diversification strategies for construction companies. A SWOT analysis can also be conducted. SWOT analysis is a powerful tool for assessing the diversification potential of construction companies. Let us consider its application to the diversification activities of these companies:

1. Strengths include:

   - experience and expertise in the construction industry, which makes it easier to execute construction projects in different markets;

   - a developed network of clients and partners that can be used to expand into new market segments;

   - availability of resources and technologies for the implementation of new construction projects in various areas.

2. Weaknesses include:

   - dependence on seasonality and economic conditions in the construction industry, which may lead to instability in the implementation of new projects;

   - high personnel and material costs, which may complicate the process of diversification and reduce competitiveness;

   - limited geographic presence or specialization in specific regions, which makes it difficult to enter new markets.

3. Opportunities include:

   - demand for energy-efficient building solutions in the context of aggravating environmental problems and rising energy costs;

   - expansion of markets through the development of urban infrastructures, residential construction, as well as in the commercial and infrastructure construction segment;

   - the possibility of using new technologies, such as 3D printing of building materials or intelligent building systems, to increase efficiency and

competitiveness.

4. Threats include:

- competition in the market, which may lead to falling prices and reduced margins for new construction projects;
- changes in legislation and regulation, such as energy efficiency standards or environmental requirements, which may require additional costs and efforts;
- the risk of changes in market demand due to changes in economic conditions or external factors, such as a crisis or a complaint.

A SWOT analysis will help construction companies objectively assess their opportunities and threats in the context of diversification and develop a strategy that maximizes their benefits and reduces their risks.

Developing scenarios or formulating diversification strategies for construction companies is creating alternative plans and strategies for expanding their activities into new areas or markets based on the results of a preliminary analysis of the collected data. To develop scenarios or diversification strategies, it is necessary to:

Analysis of internal resources and capabilities. Assess the available resources, such as staff qualifications, technical equipment, financial capabilities, etc. Determine which can be used to implement new projects or enter new markets.

1. Examine the current state of the construction services market, industry trends, customer needs and expectations. Identify expansion opportunities based on these trends.

2. Consider various opportunities for expansion, such as developing new construction products, executing projects in other industries (e.g., infrastructure, commercial real estate, repair, and renovation, etc.), entering new markets, etc.

3. Consider the possible risks associated with each alternative diversification scenario, such as financial costs, competition, regulatory changes, etc. At the same time, identify the opportunities and benefits that can be used to implement each scenario or strategy successfully.

4. Based on analyzing market conditions, company resources, and

assessing risks and opportunities, develop specific strategies and action plans for each scenario. Identify the steps required to implement each strategy and the responsible parties and resources needed to execute them.

5. After developing the diversification scenarios and strategies, evaluate each regarding its potential benefits, risks, and alignment with the company's strategic goals. Select the optimal scenario or combination of scenarios for further implementation.

The next process is to evaluate the developed diversification strategies. To do this, you can use the method described in this paper. The method involves the formation of an expert environment mainly from participants in the construction process: owners, investors, general contractors, general designers, etc. All of them are involved in the implementation and support of construction projects at different stages of the construction process, so they understand how the market functions.

After assessing and evaluating diversification strategies $D = (D_1, D_2, \ldots, D_n)$ a ranked list of strategies is formed, from which the company's management chooses the optimal one. The strategy that is chosen for implementation has a detailed plan for the implementation of all stages. Figure 4.1 shows a Gantt chart of the tasks of the strategy chosen by the management of CCC (for more details on the formation of the questionnaire and the table of results of the evaluation of diversification strategies proposed by the team of the diversification center of this company, see paragraph 3.3). This figure shows the tasks, duration in weeks, start and end dates, and transitions between tasks. Columns-weeks are highlighted in blue, where the work performed for two months is reported (the breakdown is made in two months). The last week of the two months is not displayed; at this time, the results are summarized and reconciled with the work schedule, and a work shift is formed for the next two-month period, if necessary.

The last process and module of the information technology for evaluating and selecting diversification strategies is the implementation and evaluation of the results of the diversification strategy. Evaluation of diversification results may

include the following steps: determination of key performance indicators (KPIs), financial indicators analysis, and reporting documents. If the implementation results are not satisfactory, the strategy may be adjusted. Based on the data obtained and conclusions regarding the diversification results, it is necessary to consider possible corrective actions. This may include adjusting the strategy, changing the approach to the market, or reviewing the product portfolio. Evaluating the results of a diversification strategy is an ongoing and iterative process that allows a company to adapt to changing market conditions and maximize its success in various markets and industries.

	Task	Duration	Start	End
1	Selection of location and land plots	2 w	02.03.20	17.03.20
2	Issuance of permission documents for the land	5 w	18.03.20	24.04.20
3	Completion of the plan and concept of the complex	4.5 w	20.03.20	29.03.20
4	Creation of architectural projects and building plans	3 w	15.04.20	07.05.20
5	Development of engineering systems (electricity, water supply, heating, etc.)	2 w	08.05.20	22.05.20
6	Preparation and submission of documentation for obtaining building permits.	3 w	23.05.20	13.06.20
7	Attracting financing for the construction of a residential complex	8 w	20.04.20	20.06.20
8	The budget and resource expenditure plan of the project.	2 w	01.07.20	15.07.20
9	Commencement of construction works in accordance with the developed prc	31 w	16.07.20	10.04.21
10	Completion of construction and preparation of the residential complex for co	8 w	11.04.21	13.08.21
11	Carrying out final quality control and object acceptance.	2 w	14.08.21	29.08.21
12	Transfer of residential premises to new owners or sale.	18 w	01.09.21	15.12.21
13	Providing after-sales service to home buyers.	18 w	16.09.21	25.12.21
14	Management of the residential complex.	18 w	16.09.21	25.12.21
15	Summary and performance evaluation	3 w	03.12.21	25.12.21

Figure 4.1 - Gantt chart of the strategy objectives, which was chosen by the management of CCC.

Implementing a diversification strategy for a law firm may involve expanding the geography of services. The company may expand its operations into

new geographic markets or regions. For example, if the company has so far operated only in the local region, it may consider entering international markets or markets in other areas. Also, in addition to construction, the company may consider providing related services, such as architectural design, engineering, repair and maintenance. This may allow the company to attract new customers and expand its capabilities. The company can expand its product portfolio to include, for example, the construction of residential buildings, commercial premises, infrastructure facilities, or even the production of modular building blocks. Technological diversification may also occur. Introducing new technologies in construction can help a company differentiate itself in the market and attract new customers. This may include the use of energy-efficient technologies, the digitalization of construction processes, or the introduction of construction work. Diversification can also include the creation of alliances and partnerships. The company may consider creating partnerships with other companies in the construction industry or related industries. This can help share resources, knowledge and experience, leading to mutually beneficial agreements and joint development.

When implementing a diversification strategy, it is essential to consider potential risks and challenges, such as increased administrative costs, additional resources, and regulatory compliance in new industries or regions. Using a SWOT analysis can help assess the strengths and weaknesses of the company, as well as the opportunities and threats associated with implementing a diversification strategy.

A diagram of the information technology processes for evaluating and selecting diversification strategies is shown in Fig. 4.2.

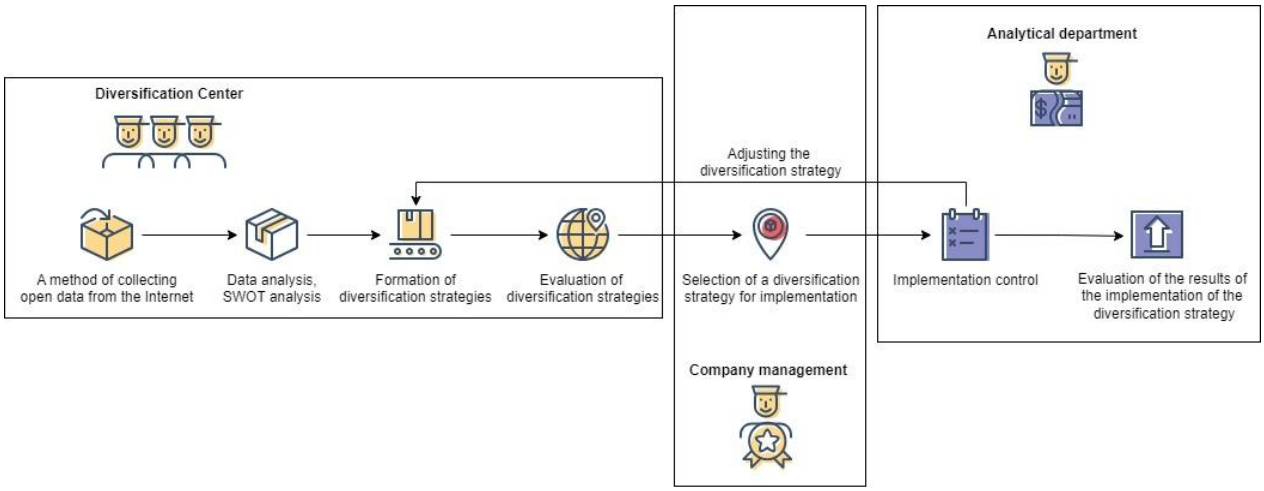

Figure 4.2 - Flowchart of information technology processes for evaluating and selecting diversification strategies

Thus, the combination of the described processes in the information technology module allows you to create a reliable and efficient decision support system for choosing a diversification strategy that will increase the profitability of a construction company, especially in conditions of uncertainty and risk.

4.2. Support for information technology for evaluating and selecting diversification strategies

Project management for the diversification of a construction company includes several key steps and business processes aimed at expanding the company's activities into new construction market segments. The basis of the company's activities is strategic planning, i.e., setting diversification goals, analyzing the market and competitors, choosing diversification strategies, etc. The development of a business plan follows this. Creation of a detailed business plan, including assessing financial capacity, forecasting revenues and expenses, and identifying resources required for project implementation. The development of a business plan is accompanied by marketing research. This involves conducting market analysis, identifying the target audience, and assessing demand and the competitive environment in the new segment. After that, it is planned to allocate the necessary human, financial, and material resources for the project

implementation, organize production processes in new market segments, ensure the quality and timeliness of work, and report. A vital management element is identifying potential risks and developing strategies to manage them. The development of information technology for evaluating diversification strategies allows you to synchronize and improve the efficiency of project-oriented construction company management components.

To support the information technology for evaluating and selecting diversification strategies, it is necessary, first of all, to ensure the availability of qualified human resources. This is due to the fact that the diversification center and analytical departments of the construction company, according to the organizational structure, perform important calculations and formulate the company's development strategy, diversification strategies and plans, etc. Finding human resources to organize the work of a construction company's diversification center is an important step, as successful diversification requires competent and experienced personnel. Here are some steps you can take to effectively search and select candidates:

1. Identify the positions and competencies required for the diversification center. These may include project managers, analysts, marketing specialists, financiers, etc. Carefully analyze the tasks and functions of the center to understand the skills and experience required.

2. Develop a job announcement that clearly reflects the requirements for candidates and expectations for job responsibilities. Determine the qualifications, experience, and skills needed to be successful in the center.

3. Use a variety of channels to find candidates, such as online job boards, social media, recruitment agencies, internal referrals, etc. Pay attention to promoting vacancies according to the profile of the target audience.

4. Prepare structured interviews to assess the technical knowledge, skills, and personal qualities of candidates. Pay attention to the specific aspects of working in a diversification center.

5. Consider not only technical skills, but also the candidate's ability to

work in a team, adaptability to change, creativity, and initiative. Conduct a reference check and analyze previous work experience.

6. After selecting the candidates, conduct the hiring process, draw up the necessary documentation, and ensure an effective process of integrating new employees into the team.

Taking these steps will help ensure the best candidates for the construction company's diversification center, which will contribute to the successful implementation of the diversification strategy. In general, information technology support for the evaluation and selection of diversification strategies covers a wide range of activities and services aimed at ensuring the smooth and efficient operation of information systems, software, and hardware. Here are some key aspects of support:

1. Technical support includes regular maintenance, troubleshooting, installation and configuration of software, network and hardware. This aspect of support is important to ensure the continuity of the IT infrastructure.

2. User support includes assisting users in solving problems with the use of programs and services, answering their questions, and training them in the use of new technologies.

3. Ensuring the protection of information and systems from intrusions, viruses, malware and other security threats.

4. Software development and improvement includes the development of new programs, improvement of existing programs and introduction of new features that improve productivity and efficiency.

5. Data and infrastructure management includes ensuring data reliability and availability, backup, data archiving, monitoring and management of the network and servers.

6. Strategic planning and consulting involves assisting in the development and implementation of strategic plans for the use of technology, as well as advising on the selection of hardware, software and IT strategies.

7. Staff training and development involves conducting trainings,

seminars and refresher courses for employees to train them in the use of new technologies and IT practices.

The use of information technology for evaluating and selecting diversification strategies will increase the efficiency of construction companies' management, in particular in terms of diversification of activities, increase the sustainability of companies in conditions of risk and uncertainty, and increase the company's profit by selecting optimal diversification strategies that provide for an increase in the economic effect of their implementation. As shown by the example of CCC.

In general, the results of the dissertation were not implemented at this company, because, as indicated, its name is anonymized to protect confidential data. The implementation was carried out on the basis of Yancheng Politechnic College (Appendix A), which is implementing several large international research projects related to the development of technologies in construction, construction management, etc. The results of this thesis will be implemented as part of one of these projects and implemented on an experimental basis. If the technology is successfully tested, it will be implemented in the work of construction companies in the People's Republic of China.

The choice of diversification strategies for construction companies under conditions of risk and uncertainty is an important task, and not all the problems that arise in this area have been solved by this study. Nevertheless, this study has provided certain theoretical and practical results that can be developed in the future and implemented in practice in the activities of real construction companies not only in China but also in other countries.

Conclusions to chapter 4

1. An improved information technology for evaluating and selecting diversification strategies for construction companies under conditions of uncertainty is described, which is distinguished by taking into account the

technical and economic parameters of construction and the preferences of participants in the construction process and allows to expand management capabilities and rationalize the choice of diversification strategies for construction companies.

2. The processes of information technology for evaluating and selecting diversification strategies are described, and the Gantt chart, which is formed before the start of the construction company's diversification strategy, is indicated.
3. It is indicated that the use of information technology will increase the efficiency of management of construction companies, in particular in terms of diversification of activities, increase the sustainability of companies in conditions of risk and uncertainty, as well as increase the profit of companies by choosing optimal diversification strategies that provide for an increase in the economic effect of their implementation.

CONCLUSIONS

The dissertation is devoted to constructing methods, models and information technology for forming, evaluating and selecting diversification strategies for construction enterprises under conditions of uncertainty. The developed methods and models can be used to solve the urgent scientific and practical task of increasing the efficiency of management and profitability of construction enterprises in conditions of insufficient information under the influence of technological, economic, political, social and other external factors, the consequences of which cannot be predicted.

The practical significance of the results obtained is that the developed methods, models and information technology for the formation, evaluation and selection of diversification strategies for construction companies is an important step in developing the theoretical and practical framework for ensuring the sustainability and profitability of construction companies. The resulting tool is important for construction companies, holdings, and the construction industry as a whole. In the long run, the use of the developed methods and models will positively impact the development of the state's legal industry as a whole. The main provisions and results of the research have been implemented and applied in the activities of Yancheng Politecnic College.

The following results were obtained:

1. The features of diversification of activities of construction companies, basic concepts, types of diversification and possible effect of diversification of activities are analyzed. The relevance of the development of the construction industry and the diversification of construction companies is substantiated. The possible consequences of diversification of construction companies, in particular under conditions of uncertainty and risk, are characterized: more efficient use of human resources, equipment and technologies, risk reduction, intensification of post-war reconstruction (in particular in Ukraine), growth of

infrastructure development, manufacturing and housing construction in countries with rapid economic growth (in particular, in the People's Republic of China). The well-known methods of multicriteria decision-making that can be applied in the context of forming and evaluating decision-making strategies for diversifying the activities of a construction company were described. It is indicated that since diversification strategies can have a significant number of evaluation criteria due to the presence of many stakeholders, financial needs, diversity and heterogeneity of the industry, the use of new or modification of known methods of multivariate decision-making can help solve the problem of evaluating the diversification strategies of construction enterprises. Since the task of evaluating the diversification strategies of construction companies is complex and has many factors of influence, it is important to develop information technology that would significantly simplify the work of a decision maker or management of a construction company.

2. It has been determined that in the conditions of uncertainty in which construction companies operate, it is necessary to change the perception of the organizational environment of a construction company, which consists of internal, external and task environments. These components of one organizational environment were described with consideration of the need to include a separate component that meets diversification objectives. Thus, as a result of the study, the conceptual representation of the structural model of the organizational environment of construction companies was further developed, taking into account the diversification of their activities and being distinguished by the fact that it organically combines the entire range of activities of companies in conditions of uncertainty.

3. The formal representation of construction technology and the task of choosing construction technology is described. It is indicated that the choice of construction technology in combination with the analysis of the competitive market and the analysis of technical and economic requirements for the task of

diversification makes it possible to thoroughly approach the formation of diversification strategies for construction companies. The concept of forming diversification strategies for construction companies was described, taking into account the principles of engineering, which takes into account six main stages from the formation of requirements for diversification activities to the evaluation of the results of implementing a diversification strategy in a construction project. The author describes a list of advantages of forming diversification strategies on the new principles: the ability to reflect complex diversification processes and management processes of construction companies under conditions of uncertainty, taking into account engineering; the ability to create, evaluate and implement diversification strategies and use a scientifically sound choice of optimal diversification strategies aimed at increasing the profits of a construction company, increasing the reliability of diversification data analysis and competitive

4. The general problem of multi-criteria selection of diversification strategies for construction companies is described, which can be used in conditions of uncertainty when the company's activities are influenced by the external environment: technological changes, political, economic and other factors. The model for selecting rational diversification strategies for construction companies based on an expert assessment of the technical and economic parameters of construction was described, which takes into account the most significant indicators and allows taking into account the preferences of participants in the construction process. These advantages, as well as the features of diversification strategies, are incorporated into the indicators of the diversification center to be created in a construction company. The method for evaluating the diversification strategies of construction companies has been improved, which is distinguished by taking into account changes in the structure of the organizational environments of companies and allows to increase the efficiency of their management. This method is based on expert evaluation and involves taking into account the opinions of all participants in the construction process: owners, developers, investors, general

contractors and general designers. The described method for assessing the diversification strategies of construction companies has been verified on the example of a construction company in the People's Republic of China.

5. An improved information technology for evaluating and selecting diversification strategies for construction companies under conditions of uncertainty is described, which is distinguished by considering the technical and economic parameters of construction and the preferences of participants in the construction process and allows to expand management capabilities and rationalize the choice of diversification strategies for construction companies.

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APPENDIX A. ACT OF IMPLEMENTATION

盐城工房职业技术学院
Yancheng Polytechnic College

ACT OF IMPLEMENTATION

The act of implementing the results of the dissertation work of PhD student Li Yuanyuan

INFORMATION TECHNOLOGY OF ESTIMATION OF DIVERSIFICATION STRATEGIES FOR CONSTRUCTION ENTERPRISES UNDER UNCERTAINTY

The commission considered in detail the results of Li Yuanyuan's dissertation research, **"Information technology of estimation of diversification strategies for construction enterprises under uncertainty"** and established:

1. Li Yuanyuan has been actively cooperating with our company for the past few years, especially on his dissertation research topic. The commission believes that Li Yuanyuan's dissertation research, "Information technology of estimation of diversification strategies for construction enterprises under uncertainty," is of significant practical interest to construction companies and the construction industry of the country as a whole.
2. In work, the method of forming diversification strategies has been improved, which takes into account the analysis of information about the activities of construction companies based on engineering and the concept of open sources, which is used to create a list of alternatives in the task of choosing rational strategies for the diversification of companies and allows expanding their management capabilities.
3. The work also improved information technology for evaluating and choosing diversification strategies of construction companies in conditions of uncertainty, which is distinguished by taking into account the technical and economic parameters of construction and the advantages of participants in the construction process and allows to expand management capabilities and rationalize the choice of diversification strategies of construction companies.
4. The method of evaluating diversification strategies of construction companies has been improved, which is characterized by taking into account changes in the structure of organizational environments of companies, which is characteristic of conditions of uncertainty and allows to increase the efficiency of their management. For the first time, a model for choosing rational diversification strategies of construction companies is described based on an expert assessment of the technical and economic parameters of construction, which takes into account the most significant indicators and allows taking into account the advantages of participants in the construction process.
5.

The decision of the commission:

Information technology, methods and models of formation, evaluation and selection of diversification strategies, which were developed by Li Yuanyuan and are part of the work **"Information technology of estimation of diversification strategies for construction enterprises under uncertainty"** provide a powerful toolkit for managing the activities of construction companies in terms of diversification of their activities. This makes it possible to increase such companies' productivity and profits in the medium term. The committee members believe that Li Yuanyuan deserves to be awarded a Ph.D. in Information Systems and Technologies.

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APPENDIX B. LIST OF THE APPLICANT'S PUBLICATIONS ON THE THEME OF THE DISSERTATION AND INFORMATION ON THE APPROVAL OF THE RESULTS OF THE DISSERTATION

Articles in professional publications of Ukraine
(included in the list of the Ministry of Education and Science of Ukraine)

1. **Yuanyuan, Li, Biloshchytska, S.** (2019). Diversification of activity as a component of adaptive strategic management of construction enterprise. Management of development of complex systems, 37, 173 – 177. DOI: 10.6084/m9.figshare.9783233 [category «B»]
   https://urss.knuba.edu.ua/files/zbirnyk-37/30.pdf
2. **Yuanyuan, Li.** (2019). Multi-criterian methods for selection of rational strategies of diversification of building enterprises under uncertainty. Management of development of complex systems, 38, 173 – 178. DOI: 10.6084/m9.figshare.9788705 [category «B»]
   https://urss.knuba.edu.ua/files/zbirnyk-38/29.pdf
3. **Yuanyuan, Li., Biloshchytska S.** (2019). The problem of choosing a diversification strategy for a building enterprise in risk conditions. Scientific Bulletin of Uzhhorod University. Series of Mathematics and Informatics, 2(35), 119-126. DOI: 10.24144/2616-7700.2019.2(35).119–126 [category «B»]
   http://visnyk-math.uzhnu.edu.ua/article/view/184236/189215
4. **Yuanyuan, Li.** (2024). Development of a method for evaluating diversification strategies for managing the activities of construction companies. Management of development of complex systems, 57, 72 – 76, https://doi.org/10.32347/2412-9933.2024.57.72-76 [category «B»]

Articles in professional publications of Ukraine
(not included in the list of the Ministry of Education and Science of Ukraine)

1. **Yuanyuan, Li.** (2020). The problem of choosing a strategy for diversification of a construction enterprise. *Science Journal Innovation Technologies Transfer*. 10-14.

Approbation works

1. **Li Yuanyuan, Biloshchytskyi A., Bronin S., Liashchenko T.** (2021). A Conceptual Model for Diversification Strategies Choice, 2021 IEEE International Conference on Smart Information Systems and Technologies (SIST), Nur-Sultan, Kazakhstan, 1-4, doi: 10.1109/SIST50301.2021.9465934. [**Scopus, Web of Science**]

2. **Yuanyuan, Li.** (2020). The problem of choosing a construction enterprose diversificstion strategy. Seventh international scientific-practical conference «Management of the development of technologies» Topic: "Information technology development of educational content» Kyiv, 25 – 26 March 2020, 133-134. [In Ukrainian]

3. **Yuanyuan, Li.** (2019). The problem of choosing a diversification strategy for a building enterprises. VI International Scientific and Practical Conference "Information Technologies and Interactions", December 20, 2019, 101-103.

4. **Yuanyuan, Li.** (2019). Problem of adaptive management and diversification of construction enterprises. I international scientific-practical conference, IMTSK-2019 (Information Modeling Technologies, Systems and Complexes), 96-98.

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6. **Yuanyuan, Li.** (2018). Strategic analysis of diversification opportunities of the building enterprise. V International Scientific and Practical Conference "Information Technologies and Interactions", November 20-21, 2018, 59-60.